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ABSTRACT

This course outline, the second volume of a two-volume set, consists of lesson plans for pre-employment laboratory training in general agricultural mechanics. Covered in the eight lessons included in this volume are cold metal work, soldering, agricultural safety programs, farm shops, farm structures, farm and ranch electrification, soil and water management, and farm and ranch surveying. Each unit contains suggested procedures and activities, an instructional outline, transparency masters, and a list of references. (MN)

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INSTRUCTIONAL MATERIALS

PRE-EMPLOYMENT LABORATORY TRAINING

GENERAL AGRICULTURAL MECHANICS

VOLUME II

P.-E.L.T.
VOCATIONAL AGRICULTURE
P.-E.L.T.

Vocational
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COURSE OUTLINE FOR LESSON PLANS FOR PRE-EMPLOYMENT LABORATORY TRAINING IN GENERAL AGRICULTURAL MECHANICS
VOLUME II

Unit M	Cold Metal Work	1. Selecting and Using Cold Metal Tools 2. Drilling Holes - Tapping and Threading 3. Sharpening Twist Drills, Cold Chisels, Punches, and Tin Snips 4. Bending and Shaping Cold Metal 5. Identifying and Using Fasteners
Unit N	Soldering	1. Soldering Procedures, Equipment, and Materials
Unit O	Planning An Agriculture Safety Program	1. Operating Tractors and Other Machines Safely 2. Fire Prevention 3. Safety Building Practices 4. Safety Reminders and Precautions 5. Agricultural Chemicals
Unit P	Planning and Organizing the Farm Shop	1. Farm Shop
Unit Q	Farm Structures	1. Planning and Constructing Buildings and Equipment 2. Planning and Building Fences 3. Using Concrete in Structures 4. Using Concrete Masonry, Bricks, Tile, and Stone in Farm Structures
Unit R	Farm and Ranch Electrification	1. Farm Wiring 2. Selecting and Maintaining Electric Motors
Unit S	Soil and Water Management	1. Planning Farm Water Systems
Unit T	Farm and Ranch Surveying	1. The Use of the Level in Land Management

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for
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in
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GENERAL AGRICULTURAL MECHANICS

Unit M: Cold Metal Work

Topic 1: Selecting and Using Cold Metal Tools

Suggested Procedures and Activities: A display of metal tools can be used as a very valuable teaching aid during the class discussion.

1. Introduction

There are many types of construction and maintenance jobs that require the use of special tools to work metal when it is cold. Iron, steel, and aluminum are three common kinds of metal that are cut,bent, shaped, and punched for many jobs. It is a common practice to work with these metals (iron and steel) cold unless the work can be accomplished much easier by rising heat. The same rules apply for cold metal tools as any other type of tool. These rules are: select only quality tools; select the proper tool for the job; keep the tools in a usable and safe condition; and use the tool properly for its intended purpose.

Transparencies Nos. 1 and 2

2. Identifying Iron, Steel, and Nonferrous Metals - Use of Metals

a. The spark test can be used to identify iron and steel. This test involves the holding of iron or steel lightly against an emery stone and observing the characteristics of the spark stream. The things to observe are:

Colors of spark stream
Shape of spark after it leaves the wheel
Number or quantity of sparks
Length of spark stream
Position of spark at wheel or emery stone

As the carbon unites with oxygen in the air it begins to burn; therefore, the more carbon the metal contains, the greater the amount of sparks will be observed.

b. Some uses of the most common types of iron and steel are:

(1) Gray Cast Iron - This type of iron is used mainly for engine bases and blocks, large pipes, water hydrants, and stoves. It is a brittle iron.

(2) White Cast Iron - This iron is used for bearings, plowshares, and plow moldboards. It is so hard that it cannot be easily machined or bent.

(3) Malleable Cast Iron - Malleable cast iron can be worked into shapes without breaking. It is used mainly for making small parts of machines.

(4) Wrought Iron - Wrought iron is used to make nails, wire, bolts, pipe, chains, rivets, horseshoes, and ornamental iron works. It can be bent, hammered, twisted, welded, and stretched.

(5) Steel - If iron has a carbon content below 1.7 percent, it is usually considered to be steel. The hardness or softness of iron is determined by its carbon content and the rate of cooling after it has been heated. Soft and medium hard steel can be welded, drilled, and cut fairly easily, whereas hard steel or high carbon steel requires special tools to cut, drill, bend, or shape. Low carbon steel is used to make nails, bolts, screws, pipe, building frames, chains, shafts, some gears, and machine bodies. Medium carbon steel is stronger than mild steel and is used to make machinery parts. Alloy steel such as chromium, silicon, nickel, manganese, tungsten, and copper are added to steel to give it certain desirable characteristics. Machinery parts such as plows, beams, braces, and other parts are made from this type of steel. Tool steel carbon content may vary from 0.5 to 1.5 percent. High carbon steel is to make cutting tools, hammers, taps, and dies. It is also used to make crankshafts for engines.

c. Nonferrous metals and their uses are as follows:

(1) Aluminum is a very popular metal that is used for agricultural and home purposes. It is a metal produced from ore bauxite. Aluminum is used for building sidings, roofing, casting in motors, wire, and conductors used in electrical work. It is used as a conductor of electricity and heat.

(2) Copper is not as light in weight as aluminum, but it is equally as important. Its more important uses are in plumbing and electrical wiring. When copper is mixed with zinc or tin, it becomes brass or bronze alloys. Brass is used mainly for hardware. Bronze is used for bearings in machinery. Copper is used for pipes, kettles, wash boilers, and telegraph wires. It is second to silver as a conductor of electricity.

(3) Lead and tin are considered soft non-corrosion metals that are used for piping waste materials and soldering. Lead is used in paints and storage batteries and as electrical wire covering.

(4) Zinc-base metals are heavier than aluminum, and they are used mainly for plating other metals (galvanizing), electric tools, and certain fuel parts on engines. This zinc coating is used to protect iron and steel from rust. Zinc alloys are used to make small engine blocks, carburetors, some portable tools, and small parts found on cars.

(5) Magnesium is actually lighter than aluminum. It can be dangerous around fires. It is used in incendiary bombs, for ladders, and for chain saws, and alloyed with aluminum.

(6) Tin is a soft, silvery metal. It is found in the raw form as tin ore. This nonferrous metal is used to coat cans, utensils, and metal roofing. It is used to make bronze, solder, babbitt, and pewter.

(7) Bronze is considered a hard base alloy. It lasts longer than brass and is used for machine bearings, medals, bells, propellers, and statues. The penny or one-cent coin is bronze. It is a copper-base alloy that sometimes contains zinc.

(8) Brass is an alloy of copper and zinc. It is yellow and ranges from 60 to 90 percent copper and 10 to 40 percent zinc. This metal is used for musical instruments, small gears, screws, door hinges, and window locks.

Transparencies Nos. 3 and 4

3. Cutting Cold Metals

Cold metal is usually cut with a hacksaw (power and manual), cold chisel, bolt cutter, or tin snips. A bolt cutter is used to cut small round stock (less than 3/8 inch). Large stock is sawed, and bar stock is either sawed or cut with a cold chisel. Sheet metal is usually cut with tin snips.

a. Layout tools are used to measure and mark metal stock before cutting, shaping, and doing other types of work with cold metal. The most common measuring devices and their uses are:

(1) The metal worker's rule is made to measure metal. It is six inches long and is graduated in 1/64, 1/32, 1/8, 1/4, 1/2, and one inch.

(2) The framing square, try square, and combination square are important measuring devices for metal work.

(3) The push-pull rule and steel tape are used when it is necessary to make long measurements. The most common push-pull rule is 10 feet and the steel tape is from 25 to 100 feet in length.

(4) Micrometers should be used when a high degree of accuracy is needed in measuring metal. Measurements can be made to the thousandth of an inch when using this tool.

(5) Calipers, both outside and inside types, are used to make fine measurements when working with metal. The caliper is usually used with a rule, micrometer, vernier, or slide caliper. The measurement is first made of the object, and this measurement is transferred to a graduated measuring tool for a reading in inches or fraction of an inch. The caliper does not have dimension numbers. Even though dividers are used to lay out lines, they can be used to transfer measurements from a rule to the material to be cut.

(6) Special marking devices are needed in metal work. The combination square can be used as a marking gauge in the same way it is used to lay out wood stock. It has a marker (a small steel scratch awl with fine point) located in the head of the square. Scratch awls are usually used with straight edges. The fine needle point can be placed against the end or edge of the measuring tool for accuracy. The double scribers are also very important marking tools. They are made of high carbon steel so that they can be used to mark all metals. The scriber is used the same way as the awl.

(7) Dividers are classed as a very essential tool in metal work. They are used mainly for marking circles. However, they can also be used to divide circles and mark equal lengths. They are sharpened in such a way that either of the two metal points can be used to sit on the metal or scratch the metal.

(8) Prick and center punches are used as marking tools on metal. The center punch is used to mark the center of a hole and to make an indentation in the metal for a drill bit. A prick punch is sharp pointed (15-degree angle to its center); therefore, it is used for layout work by locating hole centers, marking reference points, and marking lines.

(9) Trammels or beam compasses are used to mark large circles or make arcs that have radii. They can be used similarly to dividers except on a smaller scale. A trammel is made up of two points on a single beam. For metal work the beam is usually made of metal.

b. Cutting the stock with a hacksaw is one of the most common ways of cutting cold metal. The length of blades may vary from 8 to 12 inches, and they are 1/2 inch wide, .025 inch thick. Blades are available in 14, 18, 24, and 32 teeth per inch.

(1) Suggestions for using the blade are:

When cutting mild steel or cast iron over 1/8 inch thick, use a coarse blade (18 teeth per inch).

Hard steel, pipe, and heavy sheet metal can be cut with a medium blade (24 teeth per inch).

Thin sheet metal and tubing should be cut with a fine blade (32 teeth per inch).

High speed blades are usually not necessary for ordinary work. A high-carbon or tungsten-alloy blade is tough enough to resist breaking and does most jobs of a hacksaw. The high carbon blade is less expensive than an alloy or high-speed blade.

Blades are inserted in the frame by pointing the teeth away from the handle. Tighten the blade in the frame and retighten after it has been used for a short time.

(2) The steps to follow in making the cut with a hacksaw include:

Mark the metal to be sawed and place it in a vise. The mark should be placed near the jaws, especially if the metal is thin. It may be necessary to use boards between the vise jaws to prevent scarring the work. Mark over the original mark with a file.

Hold the saw with both hands and start the cut by pulling it toward the body (backward stroke). The kerf may be started without filing a notch on the metal. As the saw is pulled backward a very small amount of pressure should be applied.

The right amount of pressure should be applied as the saw is pushed forward. No pressure should be used on the back stroke after the saw begins cutting.

Steady strokes from 40 to 50 per minute are considered the correct speed for sawing.

Never start a new blade in an old cut. The teeth are set; therefore, the cut is narrower than the new blade. One stroke may ruin the teeth.

c. Cold chisels are used mainly to cut light metals and fasteners. There are four common types of cold chisels used for cutting metal: standard flat, diamond point, cape, and round nose. The most commonly used is the standard flat chisel. It is used to cut sheet metal, bolts, nuts, rivets, and rods. The diamond point chisel is used for cutting triangle grooves or for making square corners in grooves. The cape chisel is used to cut out rectangular grooves or channels. The round nose chisel is used to cut out rectangular grooves or channels. The round nose chisel is used similarly to the diamond point in that oil grooves or channels can be made by its use. It cuts an oval groove. Another special kind of chisel used to cut thick sheet metal (oil drums) is the chipping chisel.

(1) Steps in cutting flat metal are:

Mark the metal with an awl, soapstone, scriber, or chalk. A straight edge should be used to make a straight line.

Place the flat chisel at one side of the metal to start the shearing point; at the same time place the cutting edge at an angle to the work. Drive the chisel with either a machinist's or ball peen hammer. Hold the chisel loosely about the middle when striking the blows. After some practice the chisel head can be hit heavy blows without hitting the hand.

Place metal less than 1/8 inch thick in a vise and cut with a flat chisel by holding the chisel at about a 60-degree angle to the work. The cut should be just above the jaws of the vise. The point of a standard flat chisel is sharpened at about a 70-degree angle. Soft metals and sheet metal can be cut more rapidly if the chisel is sharpened to a 45-degree angle.

Cut thick metal by placing it on the cutting ledge of an anvil. Thick metal is cut in the same way as thin metal, except that it is turned over and the same cut is made on the reverse side. After the cut is completed on both sides without cutting through the metal, it may be bent back and forth until it breaks.

(2) Steps in cutting round stock are:

After the iron is marked, it should either be clamped in a vise or held on the cutting ledge or shoulder of the anvil for making the cut.

The rod or round iron should be cut from both sides, each cut being 1/3 the distance through the rod.

Break the rod at the point of the cut by bending it back and forth across the vise jaws or over the edge of the anvil.

After some practice the chisel head can be hit with heavy blows without hitting the hand. Grasp the chisel above the bevel and hold loosely in order that the hand will not be endangered if the hammer slips off the chisel head.

One of the fastest methods of cutting round iron from about 3/16 to 3/4 inch thick is to use a bolt cutter. The jaws are made of alloy-steel which will cut hard or soft bolts, rods, chains, and heavy gauge wire. This metal cutting tool should be used properly; that is, the bolt or rod cutting capacity should be observed. Usually capacity information is stamped on the handle. The procedure for using a bolt cutter is as follows:

> Spread or pull the handles apart wide enough so that a rod or bolt can be placed as far back in the jaws as possible; then pull the handles together without twisting the cutter. When using a large heavy duty cutter place one handle against the floor or ground and use both hands to apply pressure on the other handle. Note: Special hardened steel should not be cut in the bolt cutter.

Cold cutters are used sparingly in cold metal work. They function the same as cold chisels except for the fact that the cold cutter resembles an anvil hardy on one end and a hammer on the other end. This type cutter is equipped with a handle which is used to keep the cutter on the metal while it is being hit with a large machinist's hammer. It takes two people to use a cold cutter, whereas one can cut metal with a cold chisel. The procedure for using a cold cutter is:

> Mark the metal and place it on the anvil shoulder for cutting. Strike the cold cutter head with the hammer until the metal is cut about 1/3 through the stock. Turn the cut underneath and make another cut in line with the first cut. The cutting job is easier when a second person holds the cold cutter handle. After cuts are made, bend the metal back and forth over the edge of the anvil until it breaks.

d. Tinner's snips or shears may not be recognized as metal cutting tools. Snips are used mainly to cut sheet metal. The most common snips are: straight (for straight cutting) and curved (for cutting inside curves or arcs). The cutting procedure when using snips is:

> After the stock is laid out, insert the sheet metal to the back of the blades. The cutting edge of the upper blade should be over the line of cut before squeezing the handles.
>
> Stop and take a new cutting stroke before squeezing the handles together. If the blades are forced completely together, burrs and nicks will show up on the finished cut.
>
> When cutting large pieces of metal, allow the piece on the right to bend down and at the same time pull up on the left piece to provide free space for operating the snips. A left-handed person should use a left-hand snip; therefore, the piece of metal pulled up during the cutting process would be on the right.

Curves and circles should be cut with hawk's bill scroll snips. Stove pipes, cans, and vent pipes should be cut be using double cutting snips. This type of snips has three blades.

e. Special information for cutting tool steel and thin metal is as follows:

(1) It is advisable to test tool steel to determine whether or not it is in the softened stage before attempting to cut it. The saw blade or chisel may be dulled if the steel is too hard. Usually tool steel is nicked with a high carbon hacksaw blade. Tool steel can be broken by sawing about one-fourth the way through the rod or bar and then breaking it in a vise with the hammer. Heavy hammer blows should be directed toward the backside of the vise.

(2) Very thin metal may be cut with a hacksaw by placing it between two pieces of board in a vise. The cut should be made through the boards and metal. The boards and metal can be clamped to a table top instead of being placed in a vise. Sheet metal is cut with metal snips and metal cutting shears. Snips are used very often in cutting this metal. Sheet metal of 20 gauge or less can be cut with the scissor-like tool if it is soft.

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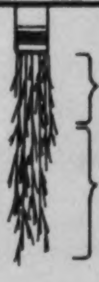
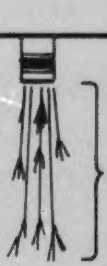
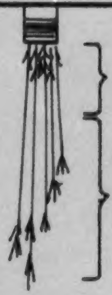
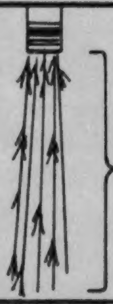
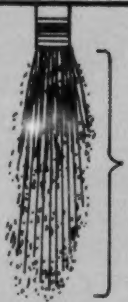
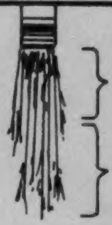
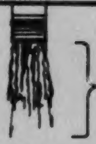
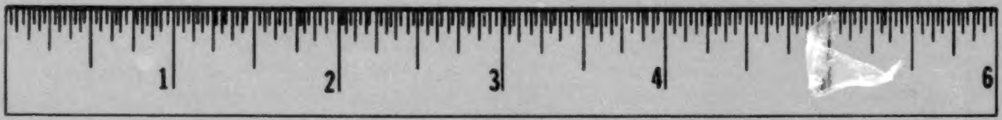
SPARK IDENTIFICATION ON HIGH SPEED GRINDER

METAL	SPARK STREAM	STREAM COLOR & LENGTH
WHITE & GRAY CAST IRON		RED STRAW YELLOW 20" to 25"
MALLEABLE IRON		STRAW YELLOW ABOUT 30"
WROUGHT IRON		STRAW YELLOW WHITE ABOUT 65"
MILD STEEL		WHITE ABOUT 70"

SPARK IDENTIFICATION ON HIGH SPEED GRINDER

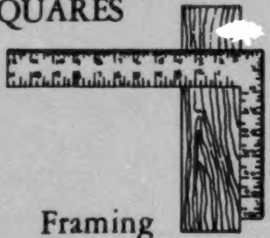
METAL	SPARK STREAM	STREAM COLOR & LENGTH
TOOL STEEL		WHITE ABOUT 55"
ALLOY STEEL		STRAW YELLOW WHITE LENGTH VARIES
NICKEL		ORANGE ABOUT 10"

LAYOUT TOOLS



METAL WORKER'S RULE

SQUARES



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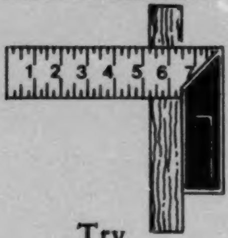

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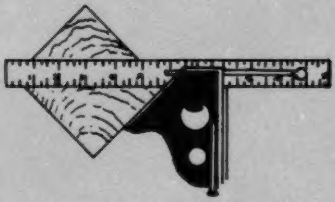

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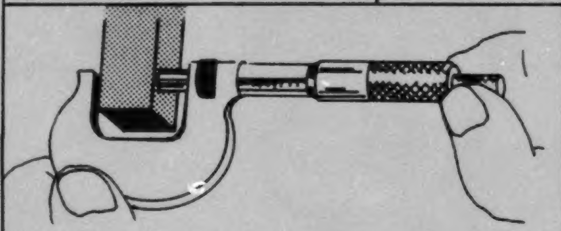
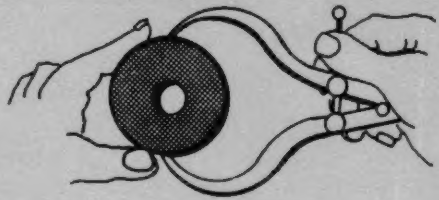
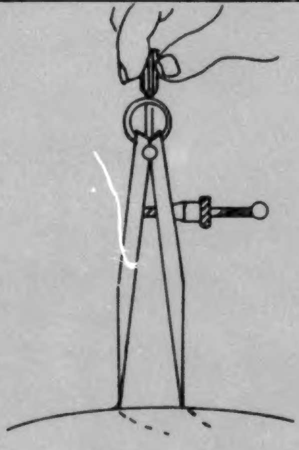


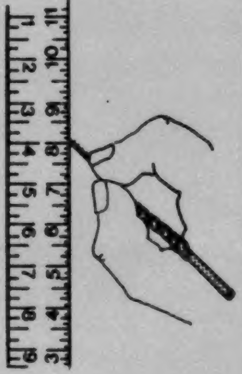
MICROMETER



OUTSIDE CALIPER



DIVIDERS



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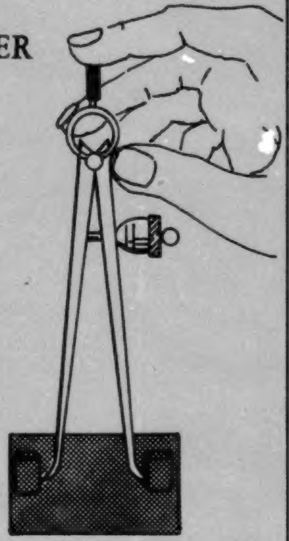
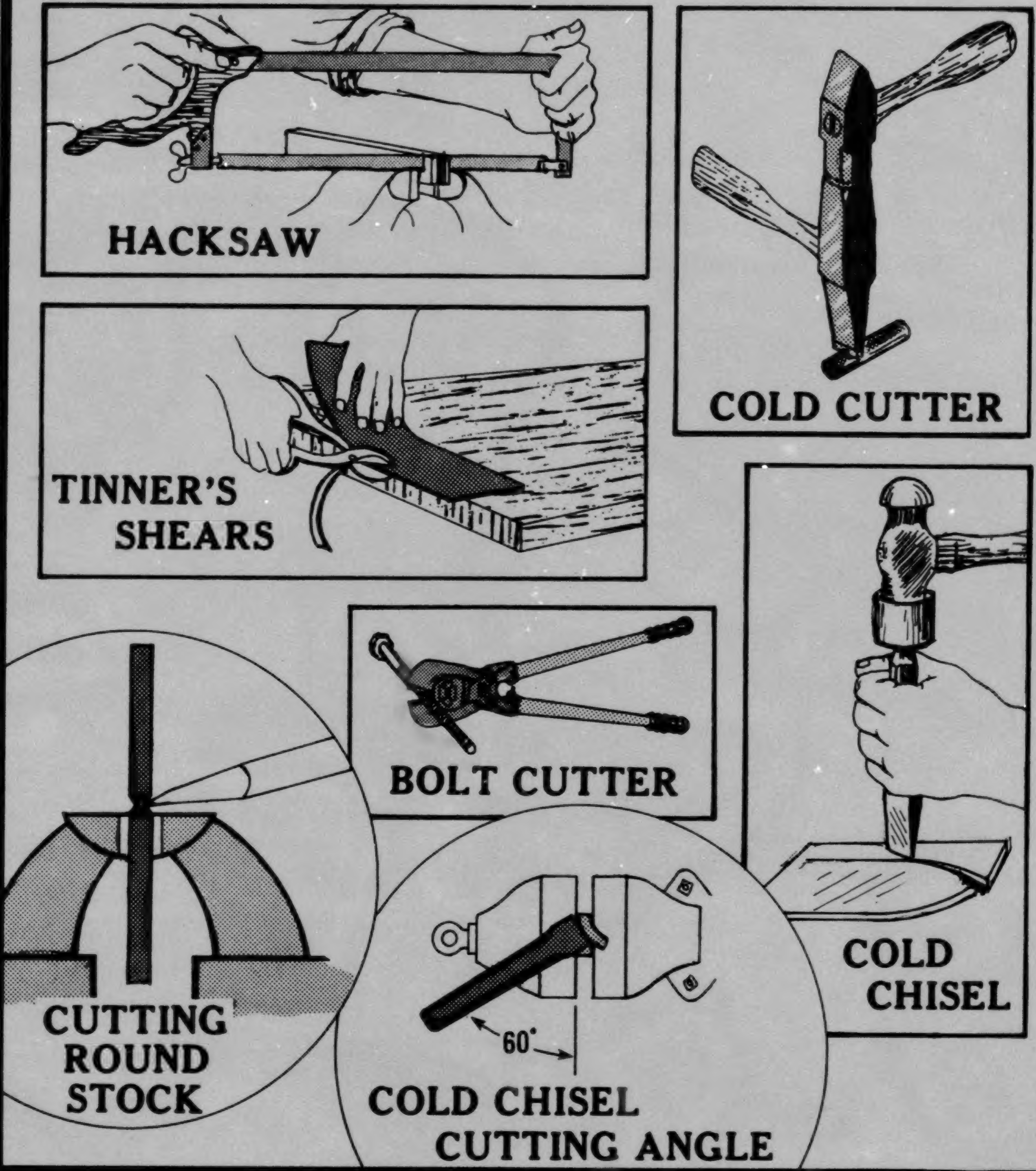


INSIDE CALIPER

CUTTING COLD METAL


HACKSAW
COLD CUTTER
TINNER'S SHEARS
COLD CHISEL
BOLT CUTTER
CUTTING ROUND STOCK
60°
COLD CHISEL CUTTING ANGLE

GENERAL AGRICULTURAL MECHANICS

Unit M: Cold Metal Work

Topic 2: Drilling Holes - Tapping and Threading

Suggested Procedures and Activities: Twist drills and a screw plate set may add to the class discussion if used as teaching aids.

1. The Importance of the Drill - Types of Drills and Drill Bits

One of the most important tools in any metal shop is the drill. It is true that one of the most widely used methods of putting together metal is welding it; but bolts, screws, and rivets also play a very important part in farm machines construction and repair. Drilling holes in cold metal, therefore, is necessary in the machinery industry and in the farming operation. Most shops are equipped with both hand and power drills. Descriptions of these drills are listed below.

a. Types of power and hand drills are:

Drill Press - The power drill press is probably used more than any other type of drilling machine in the farm shop. They are found in two models, bench and floor. A standard tilting table on the drill press varies from 17 to 20 inches square. Drill press speeds may vary from two to eight. The rpm of an eight speed drill may range from a slow speed of 38 to a high speed of 8550. Drill presses can be equipped either with tapered spindles or three jaw chucks. The three jaw chuck uses all twist drill (straight-shank) sizes up to 1/2 inch. Some heavy duty drill presses use all size bits up to 3/4 inch.

Portable Electric Drill - Cold metal that is less than 1/2 inch thick can usually be drilled with ease by using a portable electric drill. The portable drill used for most cold metal work has a chuck that will accept a 1/2 inch or smaller straight shank twist drill. This type of drill can be mounted in a drill stand for the purpose of heavier and more accurate drilling.

Post Drill - Post drills are used to drill large holes in metal. Due to the slow method of turning it by hand, the post drill will cut harder metal than other types of drills. This type of drill is not commonly used in farm shops.

Breast Drill - The breast drill is used to make holes in cold metal up to about 1/2 inch; that is, if the metal is soft and the twist drills are sharp. This drill can be used for about the same purpose as the portable electric drill.

Hand Drill - The hand drill is usually used for drilling holes 1/4 inch or less. This drill is used for light metal work. Holes for small screws, bolts, and rivets can be drilled with this tool.

b. Types of drill bits include:

Flat - This bit has no flute. It is flat on both sides with two cutting edges. The bit will cut soft to medium hard metal. It is the only metal cutting bit that can be made in the shop.

Straight Fluted - This bit or drill has two straight flutes extending the length of the body. It will cut copper, brass, and other soft metal.

Twist - This drill is one of the most commonly used in metal work. The two-lip twist drill will cut different thicknesses of solid metal. Three- and four-lip twist drills are made to enlarge holes.

Transparency No. 1

c. Twist drill shanks and parts are as follows:

Shanks - Straight, square or bit-brace, bitstock, taper or morse, blacksmith's, and rachet.

Parts - The parts of a twist drill include:

Shank - Top part held by chuck
Body - Part where grooves are cut
Flute - Grooves that run along the body
Tang - Flattened end of shank
Cutting lip - The cutting edge
Margin - Outer part of cutting edge
Point - Cone shaped cutting end

The principal parts are the shank, body, and point.

2. Determining the Size and Cutting Speed of a Twist Drill

a. Drill sizes are determined in the following ways:

(1) Fractional - This drill measurement is most commonly used in agriculture mechanical shops. Diameter of drill bits are determined by fractions of an inch. For example, they range in size from 1/64 of an inch and usually do not exceed one inch in diameter.

(2) Alphabetical - The sizes of drills are also determined by letters A through Z. The letters actually are given in size in fractions of an inch which are measured by thousandths (.234" to .413").

(3) Numerical - Alphabetical and numerical drills are often used by machinists. Drills #80 to #1 range in sizes from .0135" to .228". The #1 drill (.228") is a few thousandths smaller than 1/4 inch, and the #80 drill is a fraction larger than a human hair.

There are several types of drill gauges, but the types to check fractional, alphabetical, and numerical sizes are made of a flat or sheet type metal or plastic materials. Bits used by machinists are usually sized by numbers 80 to 1 and letters A to Z.

b. Determining the cutting by using the following procedure:

The speed of a drill is calculated by determining how many feet the outer surface of a drill will travel per minute. If the standard cutting speed for a high carbon steel bit is 30 feet per minute while drilling mild steel, then the outside surface of the bit would travel 30 feet in the steel per minute. Thus, if the bit were laid on its side and rolled on the floor, it would cover a space of 30 feet.

Example: The circumference of a circle = the diameter multiplied by 3.1416. Drills are measured in terms of inches; therefore,in order to change inches to feet the size of drill multiplied by 3.1416 (pi). divided by 12 equals the number of feet the drill will travel in one minute.

1/2 inch drill traveling at 229 revolutions per minute equals about 30 feet per minute.

$$\frac{1''}{2} \times \frac{3.1416}{12} \times 229 = \text{29.97 feet per minute or about 30 feet}$$

Recommended drill speeds for mild steel are as follows:

Diameter of Drill Inches	Revolutions per Minute	
	Carbon Steel (30 ft. per min.)	High-Speed Steel (60 ft. per min.)
1/16	1833	3667
1/8	917	1833
3/16	611	1222
1/4	458	917
5/16	367	733
3/8	306	611

Recommended drill speeds for mild steel continued:

7/16	262	524
1/2	229	458
5/8	183	367
3/4	153	306
7/8	131	262
1	115	229

High-speed twist drills should be used to cut harder metal than can be cut by carbon steel twist drills. High-speed drills are identified by a marking (HS or high-speed) on the shank. The carbon steel may not be identified by a marking on the bit.

3. Cutting Lubricants for Different Metals

Cutting lubricants usually serve two main functions when drilling steel and certain irons. A good cutting oil may serve as a coolant to take the heat from the drill and as a liquid to float metal chips away while the cut is being made. If ordinary machine oil is used, it will interfere with the cutting by excessive lubrication; therefore, special cutting oils should be used, especially if a lot of drilling is done at one time. Excessive heat will draw the temper from the drill and soften it.

Lubricants recommended for cutting different kinds of metals are listed below:

Wrought iron, malleable iron Tool steel, carbon steels	Emulsifiable oils, sulfurized oils, or mineral-lard oils
Gray cast iron	Emulsifiable oils or dry
Brass or bronze	Mineral-lard oils, mineral oils, or emulsified oils
Copper	Mineral-lard oils or dry
Aluminum alloys	Mineral-lard oils, mineral oils, or kerosene
Magnesium alloys	Mineral oils or dry

Lard oils are sometimes mixed with lubricating oils to form a cutting oil. Soluble and sulfurized type oils are prepared as cutting oils for drilling holes and cutting metals.

4. Drilling Cold Metal

Transparency No. 1

a. Steps to observe when drilling cold metal include:

(1) Use a scribe or scratch awl and mark a cross (+) on the metal at the center of the hole where the metal is to be drilled.

(2) Dent the metal where the two lines cross by using a center punch. Check the dent to see if it is centered where the two lines cross, then strike the punch with a heavy blow to form a large dent for the drill. A large center punch should be used for large drills. A proper type of punch mark will prevent the bit from slipping on the metal. If a prick punch is used, enlarge the dent with a center punch.

(3) Select the proper type of twist drill and check the size by using a drill gauge if necessary, then place the twist drill firmly in the chuck either by hand for a keyless chuck, or by the use of a key for a keyed chuck.

(4) The stock must be held firmly when drilling holes; otherwise, the drill and material may be damaged and the operator injured. When using power equipment to drill holes, the methods to hold stock are: drill press vise, the hand and v-block, c-clamp, monkey wrench, and machinist's vise.

(5) Lubricate both the drill and hole while drilling with a cutting lubricant that is recommended for the metal.

(6) Apply steady pressure to the drill so that a smooth even cut is made as the bit passes through the metal. Hold back on the pressure as the bit passes through the stock.

(7) Operate the drill at the proper speed. Large drills should be operated at lower rpm than small drills. If a large drill is turned too slowly, the cutting edges will be dulled due to wear. However, if the drill is operated at too high speed, the cutting edges will burn.

(8) To drill large holes more easily, use the two drill method. Select a drill the size of the web of the large drill and make the first hole (pilot hole), then follow with the large drill.

(9) Remove chips and shavings with a brush, blunt tool, or air when drilling

a hole. If flutes become clogged with either chips or shavings, the drill body may be twisted or broken. In order to properly clean the flutes, remove the drill from the hole, brush the flute clean, and reenter for drilling. Steel produces shavings and cast iron produces chips during the drilling process.

b. Other things to be observed when drilling holes in cold metal are as follows:

When using any type of hand drill the first precaution to observe is to hold the drill straight unless slanted or holes at an angle are to be drilled. If leaning or side pressure is applied the drill may break or be damaged.

Drilling stocks must be placed in a position that will not permit springing or shifting while the hole is being drilled. If the metal springs or shifts the bit will likely break.

The drill will stay sharper longer when drilling steel if enough pressure is applied to make the drill cut curly shavings. Pressure is lessened just before the drill cuts through the metal.

Drills are sharpened or ground according to the metal to be cut. The best cutting point for steel and cast iron is a 59-degree angle. The lip clearance is 12 to 15 degrees. Heat-treated steels are drilled with drills that have a greater cutting angle (62-degrees) and a lip clearance of about 12 degrees. Soft cast iron, wood, certain fiber materials, plastics, and hard rubber can be drilled with a sharper pointed drill than is used on hard metals. A drill with an angle of 45 degrees and a 12-degree lip clearance is recommended.

Very thin metal can be drilled without bending it out of shape if it is clamped in a vise between two pieces of board while drilling the hole.

The drill press is a very important power tool for drilling thick or hard metal. Much more pressure can be applied by using a drill press than by using hand drills; therefore, it is used more than any other drilling tool. One of the limitations in using the drill press is its limited mobility. It cannot be moved and used in different places as can the hand drill.

c. Holes that are drilled too small may be enlarged in the following ways:

A tapered reamer should be used on both sides of the metal stock. Most reamers cut rapidly, so light pressure is applied on the brace or drill handle.

A tapered punch can be used on mild steel if the hole is to be enlarged no more than 1/16 inch and the stock is not too thick. The punch should be used in both sides of the hole.

A larger drill may be used if pressure is applied very slowly. If too much pressure is applied the drill may seize or bite into the metal and break.

A rat-tail or round file may be used if a very small amount of metal is to be removed. If the hole is to be enlarged on one side, the file may be the only tool to use.

5. The Importance of Threading and Tapping

   a. Many machines and equipment and metal objects are assembled with fasteners such as bolts and nuts, screws, and rods. There are numerous agricultural mechanical projects that require the use of various sizes and types of metal fasteners with different kinds of threads. Form structures and machinery are either braced or adjusted by the use of metal rods. Cutting and reshaping threads is a common task around most agricultural or machine shops.

   b. Taps are used for cutting threads inside a nut or inside a hole. The threads of the nut or hole must be of the same type as the bolt or rod that is to be used with it. Dies are used to cut threads on round rods of metal or bolts, so that the rods or bolts can receive nuts or holes with the same thread as the bolts or rods. Tap and die sets may be made up of a single or double cutting thread types. For example, USS or N. C. taps and dies are used for cutting United States Standard or National Coarse threads. The term "USS" is being replaced with the letters N. C. The SAE or N. F. taps and dies are used to cut Society of Automotive Engineers or National Fine threads. The term "SAE" is being replaced with the letters N. F.

Transparency No. 2

6. The Different Kinds of Taps and Dies

   a. The kinds of taps are:

      (1) The taper tap is used to make threads in holes that are drilled through the metal or almost through. The six tapered threads cause the tap to start easily in the hole and cut slowly as the tap is turned.

      (2) The bottom tap is not tapered at the bottom, and the threads are the same from the top to the bottom. It is used to follow the taper and plug taps in holes that do not pass through the metal. Threads are cut to the bottom of the hole when using this tap.

      (3) Plug taps are considered very important in the agricultural mechanics

shop. This tap has tapered threads (three or four) near the end, and it is used to follow the taper tap. This tap can be used for open or blind holes.

(4) Machine screw taps are rounded on the end, and the threads extend near the end with the last two or three slightly tapered.

b. The kinds of dies include:

(1) The round-split die is adjusted smaller or larger by a setscrew located in the slit.

(2) The collet of the solid die resembles the adjustable or round-slit die, except that it has no slit or setscrew. This type of die cannot be adjusted.

(3) The two piece die is made up of two threaded cutting jaws, collet, setscrew, and guide. Jaw adjustment is made by the setscrew located in the collet.

7. Tapping Holes

a. Select a twist drill for the proper size of hole to be threaded. The size of a drill is usually determined by a chart or by using the second visible thread on a taper tap. A thumb rule for NC taps 1/4 to 1/2 inch is to drill a hole 1/16 inch smaller than the tap. Examples of tap drill sizes taken from a chart are listed below:

	National Coarse (NC)		National Fine (NF)	
Size of Bolt Thread	Tap Drill Size	Threads Per Inch	Tap Drill Size	Threads Per Inch
3	47	48	45	56
10	25	24	5/32 or 21	32
1/4"	13/64 or 7	20	7/32 or 3	28
3/8"	5/16	16	21/64	24
1/2"	27/64	13	29/64	20
5/8"	17/32	11	37/64	18
3/4"	21/32	10	11/16	16

b. Clamp the stock or nut in a vise so that it will not move from the tapping position and start the tap straight by applying a downward pressure at the same time the tap is being turned in the hole. After the tap begins to take hold of the metal, release the pressure. Turn the T-handle clockwise to cut threads.

c. Apply a lubricating oil (lard oil) as the threads are being cut. No lubricating oil may be necessary when cutting most other metals.

d. The flutes of a tap can be kept clean in most cases if a one-fourth counter-clockwise turn is made after each full turn. Also a back up of one-half turn and then making a complete turn will help to remove metal chips.

e. When tapping a hole with small size taps, use the following procedure:

First, use a taper tap until it is hard to turn, then remove it. Second, use a plug tap until it is hard to turn. Remove it. Third, insert a bottom tap and turn until tight and remove it.

Continue to repeat the process using the three taps until the hole is completely tapped. Use this three step method to tap a blind hole (a hole that does not go all the way through the work).

Clean the tap flutes before removing the tap from the hole each time. Loose chips will have a tendency to mar the threads.

Transparency No. 3

8. Threading Bolts or Rods

a. Bolts and rods may be threaded by using the following method:

Place the bolt or rod in a vise and file a slight taper or bevel on the end.

Select a proper size die and place it in the die stock, place the bevel side of the die over the bevel on the bolt or rod, and apply pressure as the turn is made clockwise. After the first complete turn, apply a lard oil or mineral-lard oil and thereafter apply the oil about every third turn. When threading cast iron, oil should not be used.

As the die is turned, punch out loose metal from the flutes or turn back the die one-fourth turn during each full turn. This backward turn breaks the chips that form on the forward turn. The die may be turned the desired length of the thread, except in the case of small diameter dies when the die flutes fill with loose metal and begin tearing the threads. Chips should be removed before removing the die.

The number of threads per inch is marked on the die; therefore, make the number of complete turns to cut the desired number of threads. If the die is marked

1/4-16, then 16 complete turns will cut one inch of threads. The exact number of threads on a bolt or rod may be determined by using a steel rule. The one inch mark should be above one thread and a count made of the number of threads in one inch.

Brush the threads clean after the die is removed and screw a proper size and type of nut on the rod.

b. General Information for Tapping and Threading

Coarse (NC) threads are used on braces, bolts, and adjusting rods in farm machinery. Fine (NF) threads are used on tractors, cars, trucks, and certain types of harvesting machines.

Agricultural mechanics shops may select a tap and die set (screw plate) that will cut NF and NC threads. A screw plate set that will cut 1/8 inch standard pipe threads, 4-36, 6-32, 10-24, and 12-14 machine-screw threads, and NF and NC threads from 1/4 inch to 3/4 inch will meet the needs of most shops. 4-36 is a number four screw with 36 threads per inch.

Rethreading is necessary when the threads are marred on a bolt or inside a nut. The same size and type of die is used to correct the threads as those to make the original threads. The use of the tap and die is the same for threading bolts or rods and tapping holes, except that the operation is much easier due to threads already being cut.

c. The following precautions should be observed while using the screw plate set:

If a tap breaks in the metal, it may be advisable to grind it level with the surface and leave it in the metal. Taps are made of very hard steel and cannot usually be removed by drilling.

Due to the hardness of the metal in taps and dies, the small sizes are very easily broken. Also, small taps must be held completely straight while tapping a hole. Even though the metal is considered hard, taps can be burned due to over-heating when entering a hole.

The bolt, rod, nut, or stock must be held in a vise or by some other method to eliminate all movement while threads are being cut. Usually, bolts, rods, and holes are threaded in a vertical position.

Hardened steel rod should not be threaded with a die. The die must be harder than the metal being cut.

Cutting lubricant should be added when turning the tap or die back and forth to remove chips while working with malleable iron or steel.

Tapping and threading jobs require special tools; otherwise, the job cannot be accomplished. The main tools are: screw plate set (die stock, tap wrenches, dies, and taps), files, punch, hammer, hacksaw, measuring tool, and vise.

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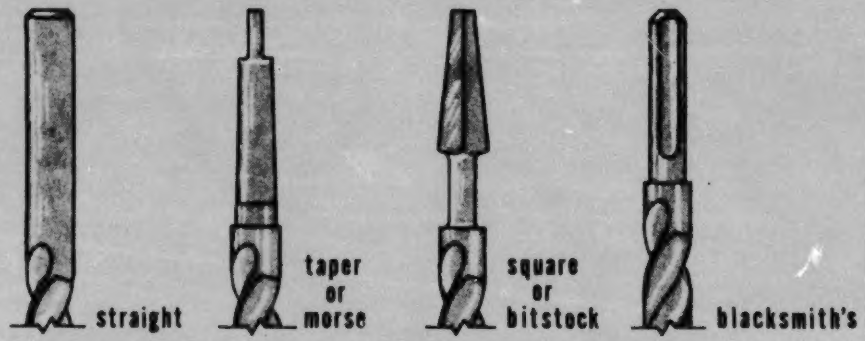
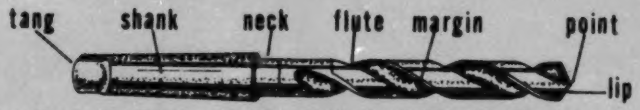
1. Boyd, T. Gardner and Others, Modern General Shop, The Goodheart-Willcox Company, Inc., South Holland, Illinois, 1975
2. Ludwig, Oswald A. and Willard J. McCarthy, Metalwork Technology and Practice, McKnight and McKnight Publishing Company, Bloomington, Illinois, 1969
3. Foss, Edward W., Construction and Maintenance for Farm and Home, John Wiley and Sons, Inc., New York, New York, 1960
4. Wakeman, T. J. and Vernon Lee McCoy, The Farm Shop, The MacMillan Company, New York, New York, 1960
5. "Farm Metal Work", University of Illinois, Urbana, Illinois, 1970

DRILLING COLD METAL

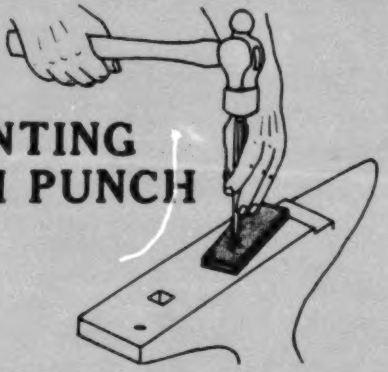

straight
taper or morse
square or bitstock
blacksmith's

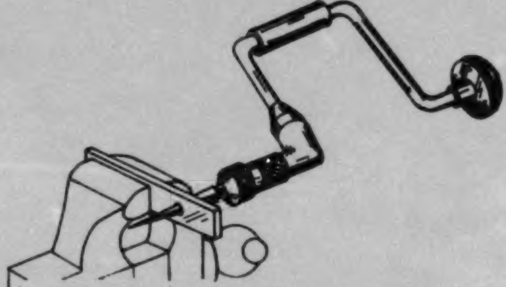
TWIST DRILL SHANKS


tang
shank
neck
flute
margin
point
lip

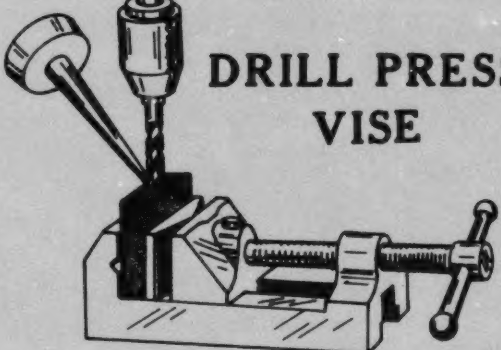
PARTS OF TWIST DRILL

DENTING WITH PUNCH



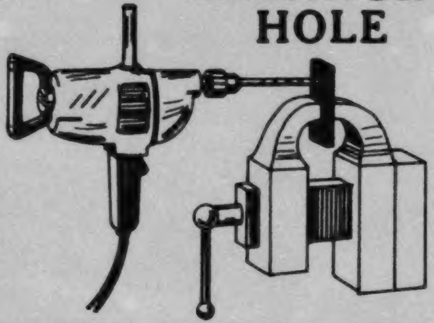


MACHINIST'S VISE

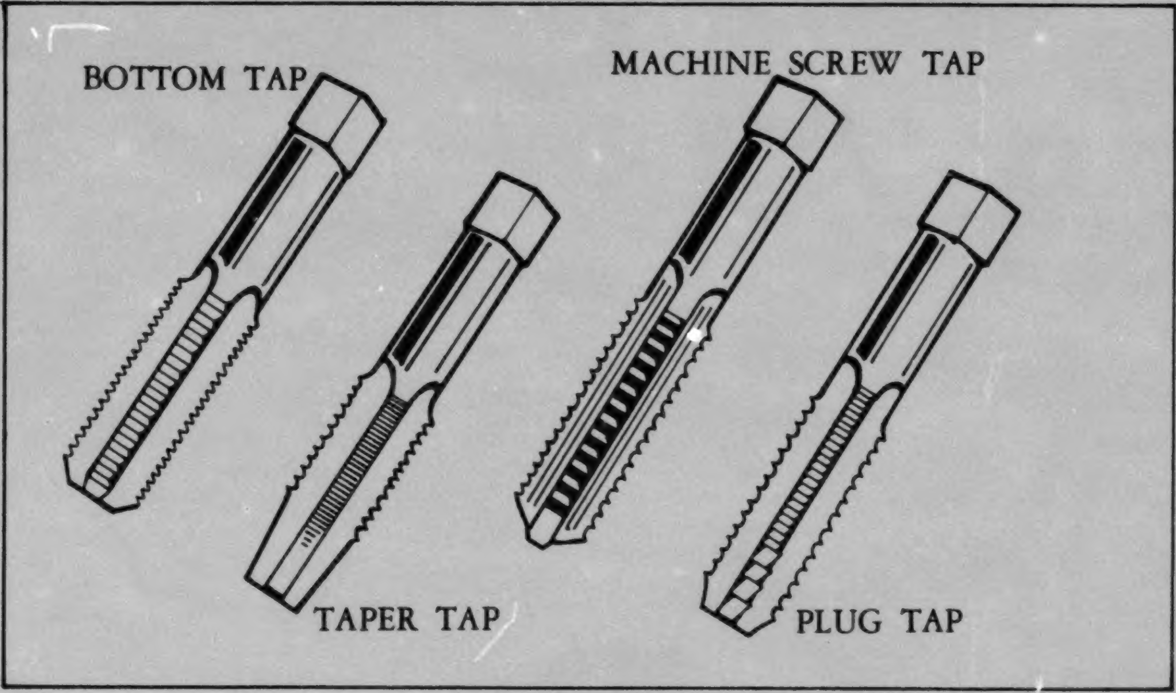


DRILL PRESS VISE

ENLARGING HOLE



TAPPING & THREADING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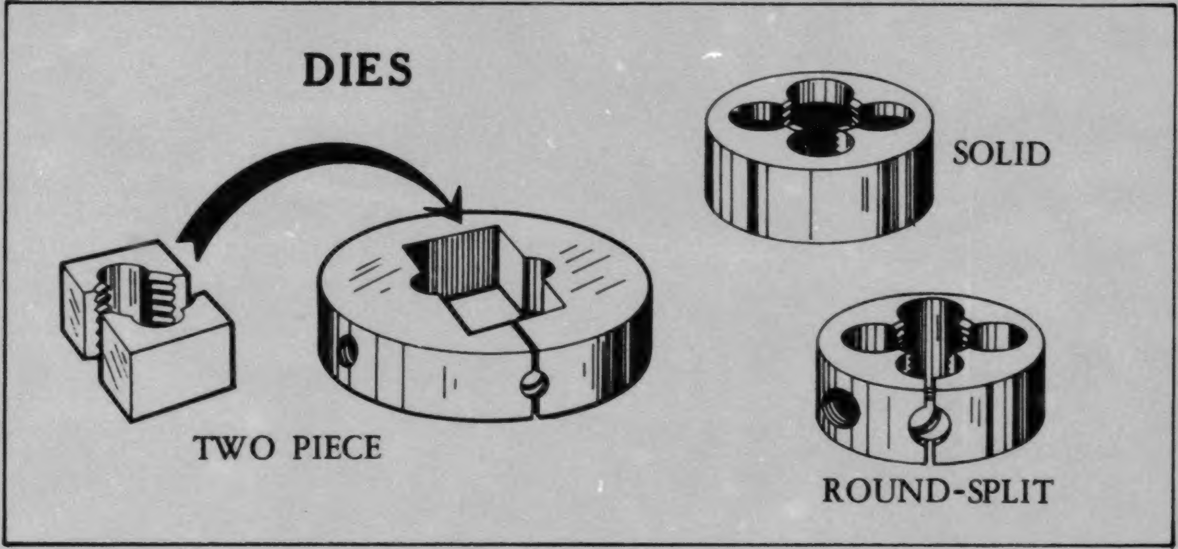
MACHINE SCREW TAP
TAPER TAP
PLUG TAP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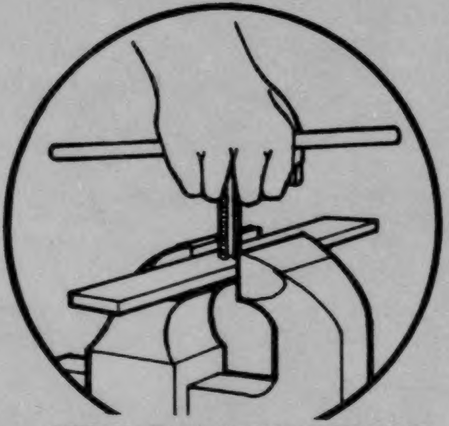
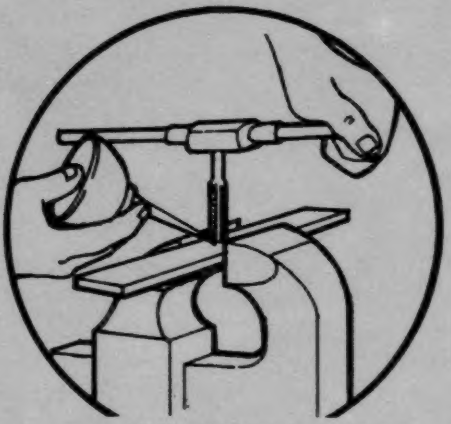
SOLID
TWO PIECE
ROUND-SPLIT

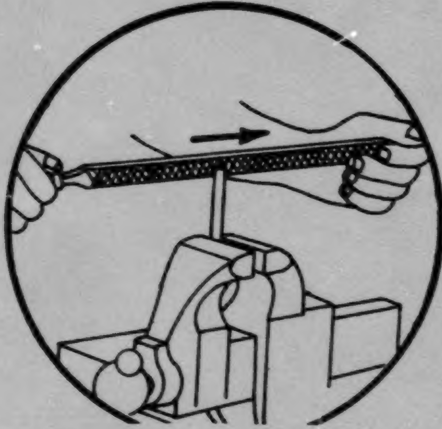
TAPPING HOLES



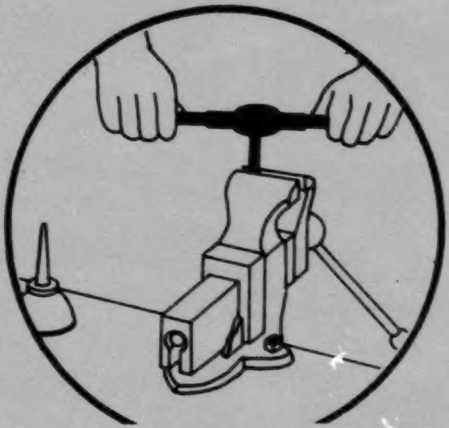
STARTING TAP



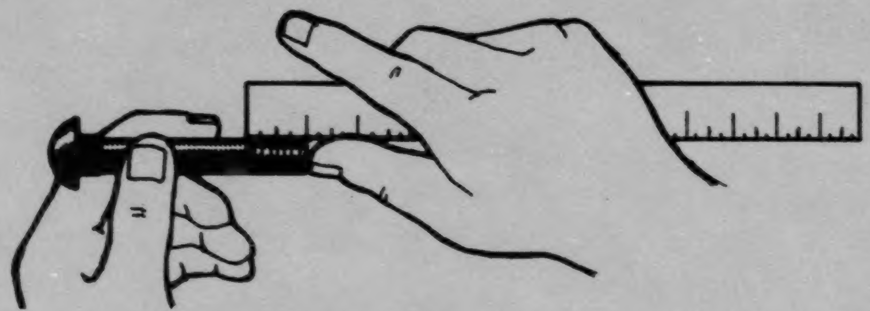
APPLYING OIL



TAPER FILING



CUTTING THREADS



DETERMINING THREADS PER INCH

GENERAL AGRICULTURAL MECHANICS

Unit M: Cold Metal Work

Topic 3: Sharpening Twist Drills, Cold Chisels, Punches, and Tin Snips

Suggested Procedures and Activities: An arrangement of both sharp and dull cold metal tools (twist drills, cold chisels, punches, and tin snips) may be used as a valuable teaching aid during the class discussion.

1. The Importance of Conditioning Metal Working Tools

Good workmanship cannot be accomplished by using tools that do not have proper edges and points. However, properly conditioned edge tools are not necessarily tools that have been sharpened to long thin bevels. Such bevels may dull quickly or break. Tools are usually manufactured with bevels that will give best results for average conditions. The metal craftman will agree that time is saved instead of being lost in keeping tools sharp. Some advantages of using quality sharp tools are as follows:

Quality work can be accomplished.

Less time is used to complete the job.

Work is less tiring and more pleasant.

Inexperienced workman is under less handicap.

Usually less danger to the workman than dull tools.

2. Equipment for Sharpening Metal Tools

There are three different kinds of sharpening equipment used in most shops. In addition to the most important piece of equipment, the bench grinder, a carborundum stone (oilstone) and different types of files are used. The three different types of grinders are:

Bench - Bench or table top type for light work
Portable - Hand type for light grinding
Pedestal - Floor type for general grinding

Transparency No. 1

a. Most shops are equipped with either the bench or pedestal grinder. However, the wet grinder (flow of water or other types of coolants pumped to the wheel) is used in larger shops where shaping as well as sharpening is part of the metal work. Information on selecting and conditioning a grind wheel is as follows:

(1) Grind wheels turn at a surface speed (distance rim of wheel will roll on floor in one minute) of 4000 to 6500 feet per minute (fpm). The popular size 6- and 8-inch diameter wheel size bench grinders may be rated in revolutions per minute (rpm). A slow speed grinder may turn at 1725 rpm, and a high speed grinder turns at 3450 rpm. There is less chance in burning or overheating the cutting edge of tools with a slow speed grinder. The fast speed usually produces a smoother finish.

(2) Grinding wheels may be selected according to the size of grain in the wheel and the grade of softness. Grade variation is caused by the amount and strength of material that holds the cutting particles together. There is also less chance in drawing temper from tools when using soft-grade wheels.

(3) There are several problems encountered in the use of the grinding wheel, but the two problems that most frequently occur are wheel loading and wheel changing shape. If the wheel is properly used, it remains free of soft materials such as wood, rubber, aluminum, brass, copper, bronze, lead, tar, paint, glue, and clay materials. A wheel that contains one or more of these materials usually becomes glazed. If the wheel is improperly used it will lose its squareness across the face.

(4) A wheel can be restored to the proper condition by removing the glaze or loaded surface with a dresser or abrasive stick. The most commonly used dressers are as follows:

Huntington Dresser - The wheel is shaped as foreign material is removed. The star-shaped cutters are held against the wheel as it rotates toward the dresser.
Diamo-Carbo Dresser - The diamo-carbo dresser is a tube filled with a very hard abrasive that removes the particles from the rotating wheel as pressure is applied against the handle of the dresser.
Diamond Dresser - A diamond set in the tube of the dresser removes foreign material and grains of abrasive as it is held against the wheel.
Abrasive Stick - A grinding wheel is dressed (cleaned and squared) when the abrasive stick is pressed against the face of the wheel. An old piece of a grinding wheel may be used in the place of an abrasive stick.

b. Grinding is considered the best method to sharpen most tools.

The edges or points of many cutting tools are made of hard metal (high carbon); therefore, files cannot be used successfully to shape the cutting edges to a fine point so they can be honed. In fact, if files are used on very hard metal, the file teeth will be damaged to the extent that the file can no longer be used on soft metal.

A neater sharpening job can be done on such tools as wood chisels and plane blades when using an electric grinder. If a blade or tool is to be hollow ground a grinder must be used to make the curved-in surface. A flat surface is formed when using a flat file.

A more polished and smooth surface is realized when using a fine grit wheel than when using a standard file. Also, a faster tool conditioning job is performed with a grind wheel than with a file.

c. Some general rules to follow when using the grinder are:

Use thegrinder shield and wear goggles to protect the eyes from metal and grit.

Grind on the side of the wheel only if a special side grinding wheel is used; otherwise, the shape of the wheel may be spoiled and the edge tool burned.

Set the tool rest near the wheel and at the proper angle before starting the grinder.

Prevent tool overheating by moving the tool back and forth over the wheel and dip it into warm water. High speed steel often cracks when dipped into cold water.

Consider the use of the grinder the first step in sharpening a tool. The cutting edge is formed by whetting the tool on an oilstone.

Transparency No. 1

3. Reconditioning Twist Drills

a. The reasons a twist drill should be reshaped are:

(1) A drill bit that is dull, nicked, overheated, or sharpened improperly for a specific job will result in inferior workmanship.

(2) Sharp bits are very important where hand drills (electric and manual) are used.

(3) Bits will not cut properly unless there is a clearance behind the cutting edge of about 12 degrees. This degree of clearance allows the cutting lips to cut into the metal.

(4) Both cutting lips should be ground to the same degree; otherwise, the bit point will not be centered. This will cause the bit to produce an oversize hole. If one lip is longer than the other, it will do all the cutting.

(5) The bit point should be slightly rounded from the cutting edge to the heel. Rounding the point requires skill and exactness. Metal is easier to cut with this type of point.

(6) The lips must be ground to about 59 degrees with the axis if it is to cut metal properly.

b. The steps to follow when sharpening a twist drill are:

(1) Place the drill point against the grinder wheel (both point and shank at the same height). Use both hands to push the drill against the wheel. The drill should be held at a 59-degree angle to the wheel.

(2) Use one hand near the bit point and wheel; raise the bit cutting point and at the same time lower the shank with the other hand during the grinding process. This action should form a clearance angle of about 12 degrees.

(3) Make slow strokes as the point is pushed against the grinder wheel. The drill bit should be slightly rotated clockwise as the point is forced on an upward sweep. Dip the bit point in water at frequent intervals while it is being ground to keep it from overheating.

(4) Rotate the drill and grind the other lip in the same manner.

(5) Use a template to check the proper angle after every few strokes. Also check for a 12-degree clearance from the front of the cutting lip to the back edge (heel).

Determine the proper lip clearance by holding the drill bit in horizontal position and level with the eye. Determine whether or not the point or center line formed in the center by grinding both lips is 45 degrees to the cutting edge. If this line is more vertical than horizontal, the bit is lacking lip clearance.

It is a known fact that twist drills cut best when sharpened properly; therefore, an amateur may prefer a drill sharpening attachment for the grinder rather than attempting to sharpen drill bits by the free hand method. Practice is necessary to learn the free hand method. A drill bit sharpened at an angle of more than 59 degrees has a tendency to do less gouging. However, the most common angle for twist drills is 59 degrees. This type bit can be used for both hard and soft metal. A bit sharpened at a 30-degree angle from the central axis is considered most practical for drilling wood.

Transparency No. 2

4. Reconditioning Cold Chisels

a. Where shops do a considerable amount of metal work, the cold chisel is a necessary hand tool. It is one of several tools that cannot be used successfully unless it remains sharp.

The cold chisel is abused in the same manner as many other shop tools; it is nicked, broken, dulled, and the head is mushroomed if used extensively. It is not the most difficult tool to reshape, but it may need reshaping more often than many cutting and punching tools.

b. The steps to follow when sharpening a chisel are:

(1) Join the cutting edge until all nicks or gaps are removed. Hold the chisel in a level position while moving the point from side to side across the stone.

(2) Hold the handle part of the chisel with one hand and place the chisel body against the tool rest at about a 65 to 70-degree angle with the handle pointing down.

(3) Use the fingers or thumb of the other hand to apply pressure and help guide the point from side to side on the wheel. A slight swing of the chisel handle will give the chisel a curved cutting edge. Dip the point in water frequently while grinding it to keep it cool.

(4) Grind both sides of the cutting edge in the same manner.

(5) Check for the desired angle of bevel. The angle should be checked during the process of grinding both bevels. An angle gauge may be determined by cutting a V 3/8 inch deep and 1/2 inch wide in a piece of thin metal. This template will have two 70-degree sides.

(6) If a mushroom head is formed on the chisel, grind it off at the same time the chisel is being sharpened. Pieces of flying steel from the head may cause accidents. Also grind the cutting edge corners to make them slightly round. If the chisel is ground to the point that it is too thick at the end, it may be necessary to heat the chisel, draw it out,and retemper the cutting point.

(7) Hone the point by using a medium grit oilstone to remove the wire edge that was formed by grinding.

Transparency No. 2

5. Reconditioning Punches

a. The center punch is placed at a 30-degree angle to the cutting wheel face, and then move the punch from side to side on the tool rest of the cutting wheel. Allow the punch to roll as the point is being cut. The cone-shaped point should have an angle of about 60 degrees. The point should be dipped in water frequently while it is being ground to prevent overheating.

b. Pin and taper punches are reshaped by holding the punch at a 90-degree angle to the grinding stone shaft. Rotate the punch while cutting the end square and forming sharp edges.

Transparency No. 2

6. Reconditioning (Sharpening) Tin Snips

a. Tin snips are not sharpened with a knife-like cutting edge. This snip is actually a shear, in that both cutting edges cut with a shearing action.

b. The steps that may be used to sharpen tin snips are:

(1) If the tin snip metal is not too hard it may be best to sharpen them with a file. It is usually not necessary to remove the center screw to take the blades apart when using a file. However, even this method of sharpening is made easier when the blades are separated.

(2) When sharpening with a file, place the blade in a vise and use the draw-filing method (with both hands on the file, pull it over the cutting edge). Hold the file at the proper cutting edge angle as it is pulled over the blade. A smooth mill file is recommended for this sharpening job.

(3) If the blades are to be ground, hold them at the proper angle against the grinding wheel. Very light pressure should be used as the blade is moved across the wheel from the center screw area to the snip blade point. A fine grit grinding wheel is recommended. Do not grind the back side of the blade.

(4) Hone the blades on a fine oilstone. As the blade is pushed back and forth across the stone hold the blade at the proper angle. Place the back of the blade flat on the stone, and move it back and forth to remove small metal burrs or curled metal due to cutting the cutting edge.

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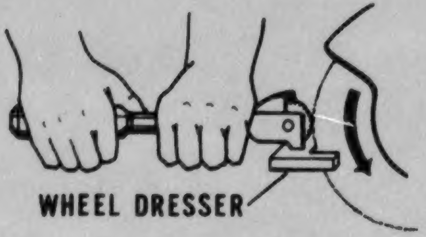
1. Phipps, Lloyd J., Mechanics in Agriculture, The Interstate Printers and Publishers, Inc., Danville, Illinois, 1967

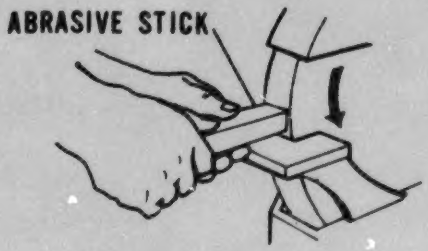
2. Wakeman, T. J., and Vernon Lee McCoy, The Farm Shop, The MacMillan Company, New York, New York, 1960

3. "Farm Metal Work", University of Illinois, Urbana, Illinois, 1970

RECONDITIONING TWIST DRILLS


WHEEL DRESSER

DRESSING STONE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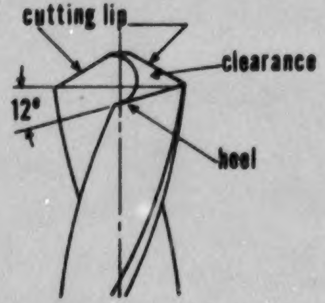
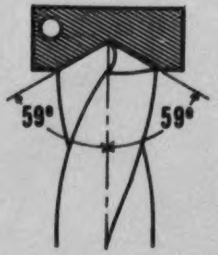
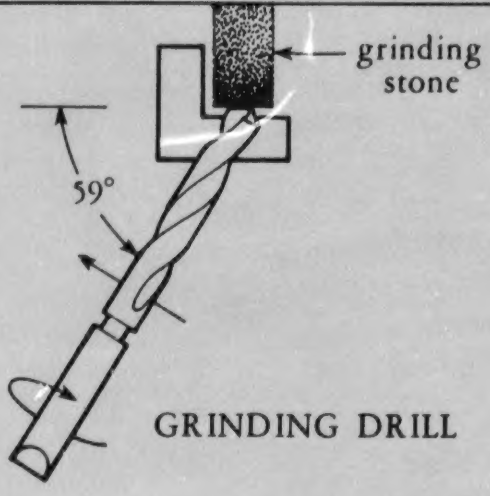
DRESSING STONE


cutting lip
clearance
12°
heel

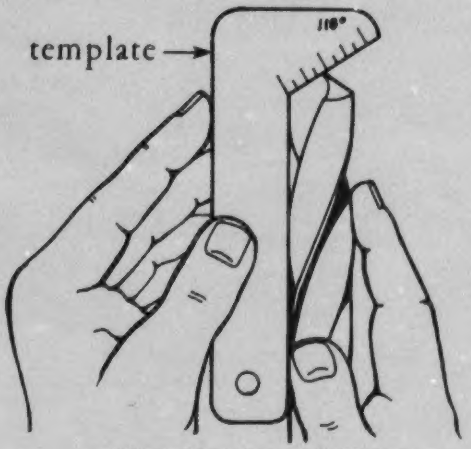
PARTS OF TWIST DRILL



TWIST DRILL ANGLE

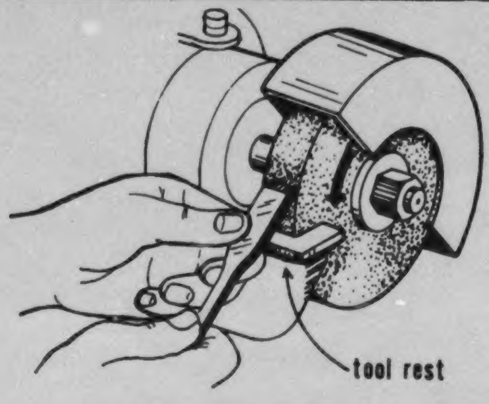

grinding
stone
59°

GRINDING DRILL

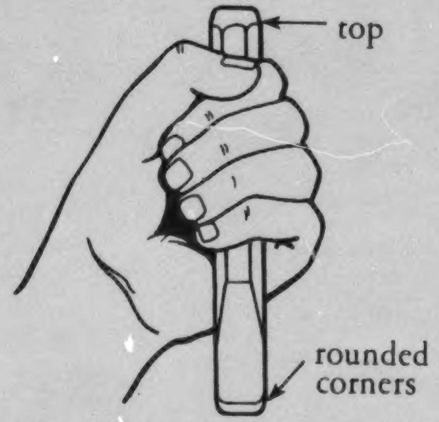

template
110°

CHECKING ANGLE

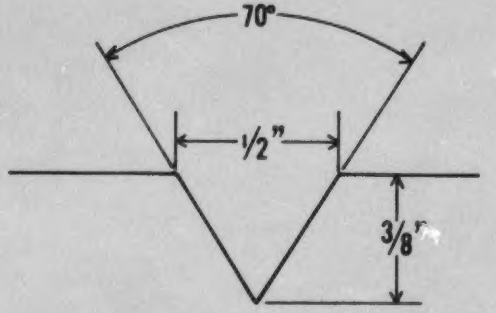
SHARPENING CHISELS AND PUNCHES



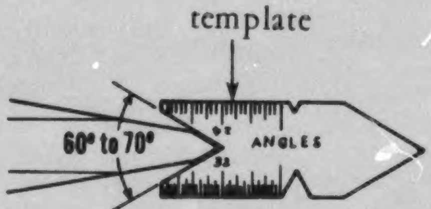
GRINDING CHISEL


top
rounded corners

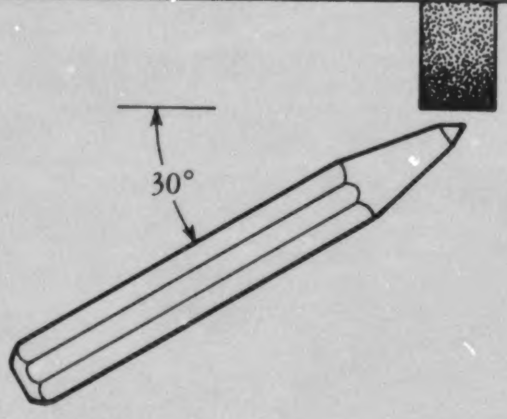
CONDITIONED CHISEL



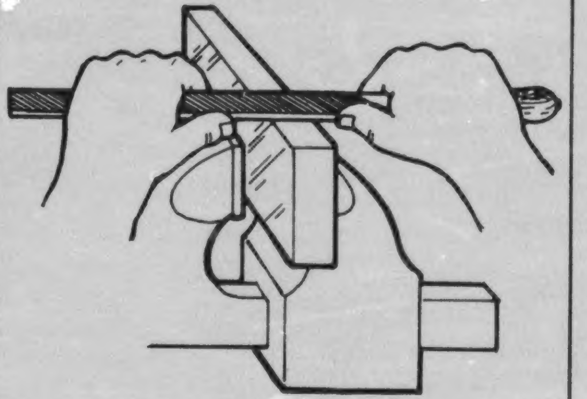
TEMPLATE-ANGLE GAUGE


template
60° to 70°
ANGLES

CORRECT CHISEL ANGLE



GRINDING CENTER PUNCH



DRAW-FILING

GENERAL AGRICULTURAL MECHANICS

Unit M: Cold Metal Work

Topic 4: Bending and Shaping Cold Metal

Suggested Procedures and Activities: Hand tools and jigs for working cold metal may be used during the class discussion.

1. Purposes of Bending and Shaping Cold Metal

a. Much of the ornamental iron work is accomplished through working with cold metal. There are numerous projects that can be made in the agricultural mechanics shop by bending and shaping cold metal. Some of these projects are braces for farm equipment, gate and door hardware, shelf framing and supports, metal projects requiring ornamental design, and hardware for truck and trailer beds.

b. Flat iron and bars can be bent and shaped up to 3/8 inch in thickness without heating. Round iron can be bent up to about 5/8 inch in diameter. Thick metal, both flat and round iron, should be heated before bending. It takes less physical strength to bend and shape hot metal than cold metal. If the metal is too thick, or too hard, extra stress is placed upon the vise, jigs, and other equipment used to shape it. Good judgment, therefore, must be used in determining whether or not heat is necessary for shaping the metal.

2. Tools Used to Bend and Shape Cold Metal

a. The most common tools used to shape cold metal include:

Blacksmith's vise
Machinist's vise
Anvil
Bending jigs
Measuring tools
Piece of pipe and rod

Sledge hammer
Blacksmith's hammer
Machinist's hammer
Monkey wrench
Marking tools
Ball peen hammer

b. Tools for shaping metal may be of different sizes. Flat iron less than 1/4 inch thick can be bent with a 1-1/2-pound hammer very easily, but when the iron exceeds 1/4 inch in thickness, a 2-1/2-pound hammer may be necessary to shape the metal. It is very important to use the proper size jig; otherwise, it may be damaged if the metal exceeds the size recommended for the jig.

Generally, metal bending should be a type of work that requires the use of heavy duty blacksmith's or machinist's vises. The sledge hammer should not be used against a vise, and it should not be used on the anvil if the weight exceeds the weight of a heavy machinist's hammer. Heavy duty monkey wrenches are preferred to light weight wrenches.

3. Types of Iron Used

   a. Flat iron that is used for making objects or projects by bending or shaping is usually black mild steel. It cannot be hardened due to its low carbon content. It may be known as blacksmith's steel, soft iron, and machine steel. It can be found in various widths and thicknesses.

   b. Round iron, which is more commonly known as rod steel or rod iron, and square rod iron or bar shaped iron of the mild steel type is bent in a similar way as flat iron for objects or projects.

   c. Angle iron is molded into the angle form to give it strength; therefore, it is bent in a shop to form corners. Much of the angle iron is made of mild steel, although some angle iron is made of wrought iron.

   Wrought Iron - This is a tough malleable steel that can be bent and shaped in the same way as mild steel. In fact, flat, round, and bar wrought iron is used to make objects and projects in Agricultural Mechanics.

4. Bending and Twisting Cold Metal

Transparencies Nos. 1 and 2

   a. A procedure for bending cold metal is as follows:

      (1) Measure and mark the metal to be bent. Place the mark above the jaw one-half the thickness of the metal. Half of the bend will be made below the mark and half above. Fillers can be used on each side of the vise jaws to protect the metal.

      (2) Bend long bars or straps of metal by pulling downward on the end, and finish the bend by hammering with a machinist's or ball peen hammer.

      (3) Bend short pieces by slipping a pipe over the end and pull downward. Short or heavy pieces can be bent by using only the hammer and heavy duty vise. Heavy and short pieces can also be bent by sawing about one-

third the distance through the bar or rod and placing the cut just above the jaws or where the bend is to be made. After the bend is made the cut is welded.

(4) If a large curve is to be made in a bar or rod, place the metal between loose jaws and bend slightly as the metal is slipped through the vise jaws.

(5) Check the degree of angle with a try square, combination, T-bevel, or a template after making the bend. If the angle is smaller than 90 degrees and a 90-degree angle is desired, the angle can be corrected on an anvil.

(6) Make a round bend (an eye) by selecting a round stock (pipe or rod) the same diameter as the eye desired. Make the eye by using the following steps:

(a) Place the flat metal and round stock in the vise. The flat metal should extend at least half the distance of the round stock diameter. Bend the metal over the stock by pulling downward with one hand and hammering the metal with the other hand. Bend until the metal is level with the vise jaws.
(b) Loosen the vise grip and extend the bent end of the flat stock to the bottom and center of the round stock and repeat the bending step.
(c) Loosen the vise grip again and place the U-shaped end of the flat stock around the shaping stock and at the top edge of the vise jaws, and repeat the bending step for the third time. Each time the flat stock is placed in the vise, the straight part should be parallel to the vise jaws.
(d) After the eye is formed, loosen the grip once more to set the flat stock parallel to the jaws. Bend the flat stock enough to put the eye in the center of the long part of the stock.
(e) Mild iron can be bent by using an anvil and hammer. Bend the iron by using the following method:

> Start the bend by hammering the iron on the end as it is held against the anvil horn. Continue hammering and at the same time move the iron to the smaller part of the horn. Make an L bend after the eye is about two-thirds finished, and continue bending the iron until the end touches the L bend, forming a complete circle.

(7) Metal bending forks and jigs are very useful for making certain types of bends when working with thin metal. A pattern or actual size sketch is very important when using bending forks or jigs. Steps in using these bending and shaping methods are as follows:

(a) Use a piece of string or copper wire by starting at one end of the drawn object and follow the pattern through curves and bends to the opposite end. This method of measurement will determine the length of metal needed.

(b) Start the end bend on an anvil. Shape and peen the ends if necessary.

(c) Place the bending fork or jig in a vise and secure firmly.

(d) If the posts are adjustable on the jig, adjust to the thickness of the stock to be bent.

(e) The curves and angles are formed with bending forks or jigs by the use of hands, pipe, and hammer. Slip a pipe over the iron if it is necessary to use this type of leverage, to give extra support when applying pressure. Usually, stock that is more than 1/4 inch thick must be bent in a vise.

b. Procedure for twisting cold metal is:

(1) Select a metal stock longer than the exact measurement needed because twisting shortens the stock. Flat or square pieces of thin metal can be twisted without heating.

(2) Mark the beginning and end of the twist with a center punch or chalk before clamping the stock in the vise.

(3) Clamp the stock in the vise so that the bottom mark will show just above the jaws. The twist should extend to the mark or top of the jaws.

(4) Place a monkey wrench just above the top mark with jaws tight and turn until the desired number of twists are complete. Proper twisting will strengthen the metal, whereas excessive twisting tends to weaken the metal.

(5) Long metal stock may have a tendency to bend; therefore, use a close fitting piece of pipe slipped over the stock. The pipe should be the length of the twist.

(6) Cut the stock to the desired length after twisting it.

c. Metal ends are usually shaped with a hammer and anvil, plus the use of a file or grinder. To flatten the ends of flat iron, the metal end is placed on the anvil face, and the end is shaped or flattened with a ball peen hammer. If the metal is to be decorated, the peen part of the hammer should be used on the end, or any place on the flat surface. The ends should be shaped before the metal is placed in a vise or jig. The end shape may be drawn on an actual size drawing or pattern, only when metal is bent.

The object or project should be checked frequently for shape and measurements by placing it over a drawing. If a bend is too short or too long, a vise or anvil may be used to make the correction.

Transparency No. 3

5. Filing Cold Metal

The file is used for smoothing and shaping metals. Shaping actually includes three types of file use: sharpening of tools, smoothing metal surfaces, and cutting metal to the desired form and dimensions. A regular mill file can also be used to test the hardness of metal. The degree of hardness will determine the type of metal cutting tool and/or the type of hacksaw blade to use for making the cut.

a. Files are selected according to their many uses. The use of a file determines the size, type of teeth, coarseness, and shape.

(1) File Sizes - File sizes are determined by the length of the file (in inches) excluding the tang or the distance from the point to the heel. A 10-inch mill file is used for general purposes. A 12-inch flat file is best for rough work and will last longer than a 10-inch file.

(2) File Teeth - There are two major kinds of file teeth, single-cut and double-cut. Single-cut files have chisel-like teeth running at an angle across the belly and body of the file. Double-cut files have two sets of teeth or chisel cuts that cross each other. Single-cut files cut slower than double-cut files, and they leave a smoother surface.

(3) Grades of Teeth Coarseness - The grade of coarseness is determined by the distance between the rows of teeth. For example, the longest spacing is called rough, and the least spacing is dead-smooth. Naturally, the coarseness changes with the length. A long file is coarser than a short file.

(4) File Shapes - The shape or style is also determined by the different uses. The most common are mill, flat, square, round, half-round, and taper or three corner files. A description of these files is as follows:

(a) Mill files are made only with single-cut teeth and range in size from 4 to 16 inches. They are used for drawfiling and finishing work such as finishing brass and bronze metals.
(b) Flat files are double cut and about 4 to 16 inches in length. They are tapered similar to the mill file and are the most commonly used of all files for general work.
(c) Square files have four filing edges instead of two as found on the mill and flat files. They are tapered or blunt and double-cut. This kind of file is used for filing corners and slots and for surface filing.
(d) Round files are single or double cut. They are used for enlarging holes,

filing curves, and forming fillets. These files are tapered from shoulder or heel to point.

(e) Half-round files have one flat side and one partly round side (about one-third of a circle). This type of file is double-cut, and it can be used to file either flat or curved surfaces.

(f) Tapered files are found in many shapes. The triangle, contour, and crosscut files are the most popular. They are double cut and are used to file corners that are less than 90 degrees and to file saws.

b. There is a correct way and many incorrect ways to hold a file for both heavy and light filing.

(1) Heavy Filing - The handle is held in one hand by placing the thumb or forefinger on top of the file handle and gripping the point with the fingers and back part of the thumb.

(2) Light Filing - The handle may be held the same way as in the heavy filing method. The file point is held between the first two fingers and thumb, applying light to moderate pressure as needed.

c. The steps to follow when using a file to shape metal are:

(1) Clamp the stock (metal) slightly above the jaws of the vise to eliminate vibration while filing. The area being filed should be about elbow height or slightly below. Chattering can be reduced or almost eliminated if the stock is placed just above the jaws of the vise.

(2) Select the proper type file to cut the stock. For example, if the surface is to be filed flat, select a flat file.

(3) Stand slightly to one side of the work, yet facing it so that the right amount of pressure can be applied on the forward stroke.

(4) Use moderate speed strokes. However, hard metal is filed slower with more pressure than mild or soft metal. About 30 strokes per minute may be appropriate.

(5) Except for draw filing, hold the file at a 90-degree angle to the side of the stock when making filing strokes on flat metal.

(6) Make a slow, full-length stroke by placing the file on the stock and pushing it forward; lift it on the back stroke. Moving the file back, permitting it to slide over the metal, will dull the teeth faster than pushing the file forward. If there is a possibility of the file slipping off the stock on the forward stroke and marking or damaging the jaws of the vise, the stock should

be clamped between two pieces of board.

(7) Check the stock with a square during the filing process to see if a proper cut is being made. A 90-degree cut is easily checked by using a try square. It may be necessary to file the stock by holding and pushing the file in a diagonal position to keep the surface flat.

(8) Clean the file periodically while it is being used. Cleaning tools are a wire brush or file card. Hard-to-get chips can be removed with a clean wire. Some of the chips can be removed by tapping the file on the work bench. Cleaning can be aided by starting the file body at a different place on each forward stroke.

d. Drawfiling is a method of filing long, flat surfaces and rods. It is also used to smooth rods that may require considerable hammering. The method is as follows:

(1) After the stock has been clamped high enough in the vise to clear the fingers, grasp each end of the file, placing it on the stock with each thumb clearing the stock by about 3/4 inch. Use a mill file which is single-cut.

(2) Apply steady pressure as the file is pushed forward. Release the pressure on the return stroke. Actually, when drawfiling, the file is pushed sideways for cutting. Always hold the file flat while the moderately slow strokes are being made on the stock. It may be necessary to clean the file often when drawfiling mild or soft metals.

e. It is important to test metal for hardness before attempting to file it. Generally, it is advisable to place the metal stock in a vise in order to run the file over its surface an inch or two to determine metal hardness. Cutting characteristics of five different types of metal include:

(1) Extremely Hard Metal - The file will slide over the metal, leaving the file dull and shiny. The file must be harder than the material being cut, and it should not be used on hardened steel.

(2) Hard Metal - The file may barely cut into the metal, but it is dulled if considerable pressure is applied.

(3) Medium Hard Metal - This type of metal can be filed without dulling the file immediately.

(4) Soft Metal - The file teeth bite into the metal very easily and become clogged with metal particles. Soft metal is cut without dulling the file. Very little pressure is applied to the file when cutting soft metal.

(5) Cast Iron - The outer surface of cast iron is considered very hard; therefore,

an old file should be used to cut through the outer surface before using a new file. If scale is present, it should be removed with a chisel and hammer before attempting to file the surface.

f. A file requires special care if it is to be used over a long period of time. The following suggestions may be observed:

   (1) Store files in racks away from other metals. If they rub or fall against other files or tools, the teeth may be damaged. Files are very brittle and may be broken if allowed to fall on concrete floors.

   (2) Keep files away from oils, paints, and caulking compounds, as these materials clog the teeth. Also, the file may corrode if placed in a humid or moist location for a long period of time.

   (3) A file should never be used without a well seated handle on the tang. Recheck the seating before storing.

References:

1. Ludwig, Oswald A. and Willard J. McCarthy, Metalwork Technology and Practice, McKnight and McKnight Publishing Company, Bloomington, Illinois, 1969

2. Miller, Rex and Thomas J. Morrisey, Metal Technology, Howard W. Sams and Company, Inc., Indianapolis, Indiana, 1975

3. Wakeman, T. J. and Vernon Lee McCoy, The Farm Shop, The MacMillan Company, New York, New York, 1960

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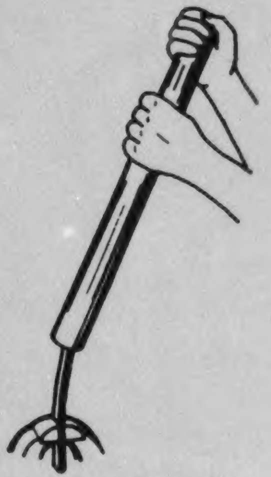
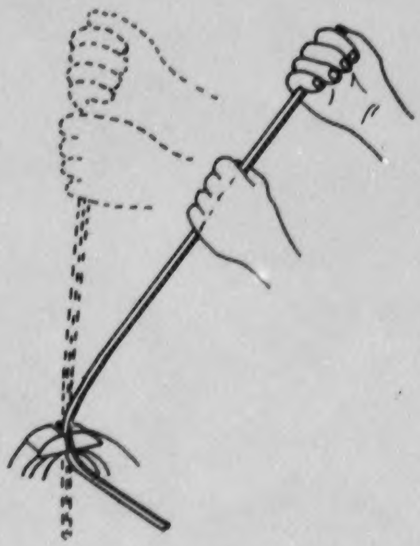
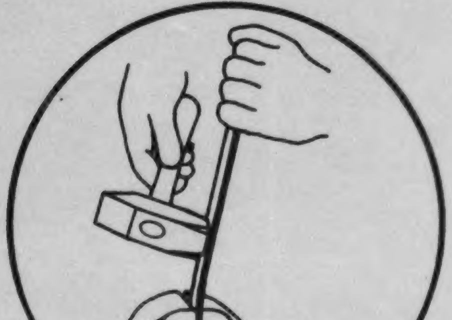
BENDING METAL



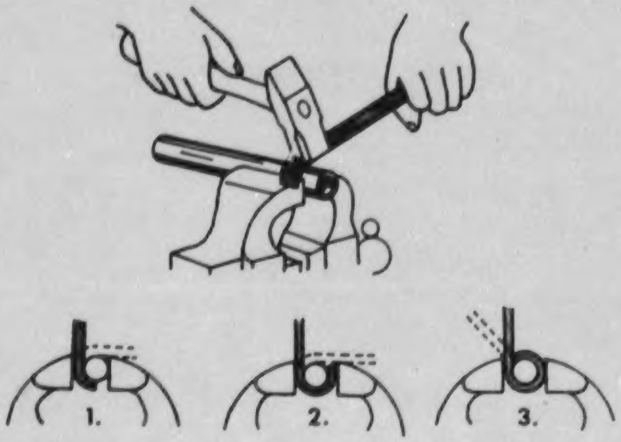
BENDING SHORT PIECES



MAKING CURVE

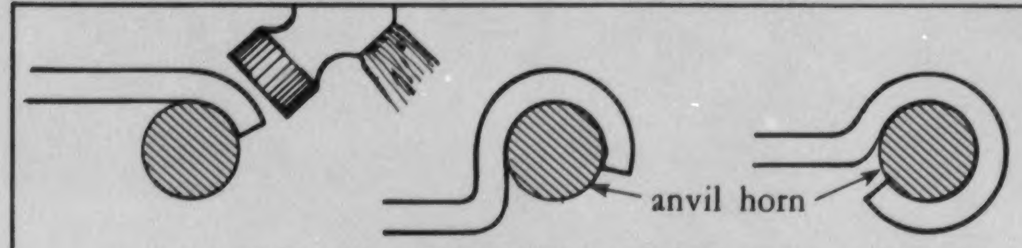


BENDING LONG STRAP

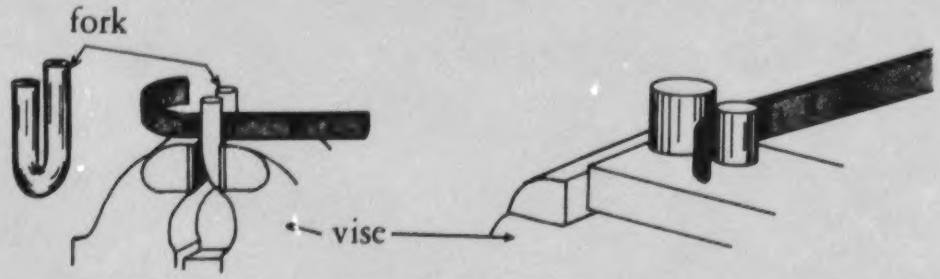


MAKING ROUND BEND

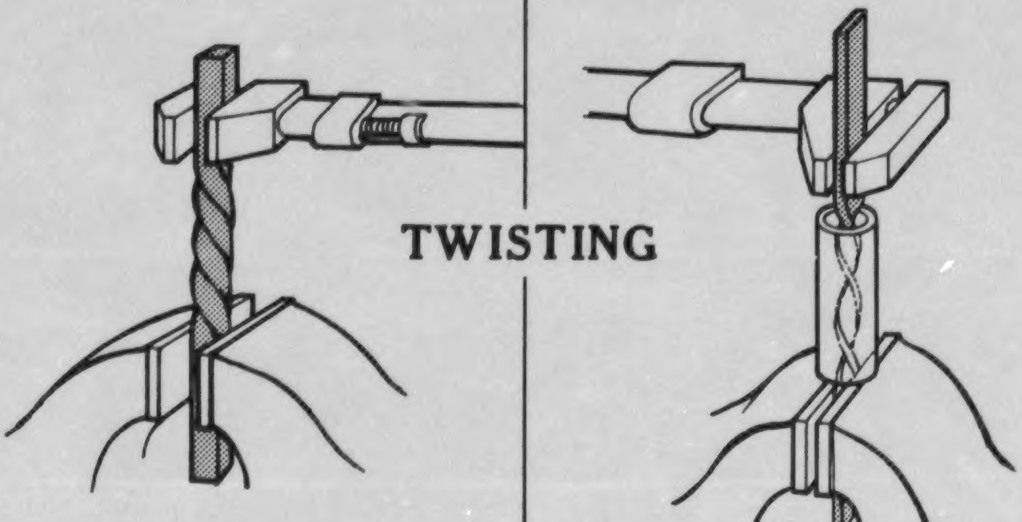
BENDING & TWISTING METAL



MAKING ROUND BEND ON ANVIL



METAL BENDING FORK & JIG

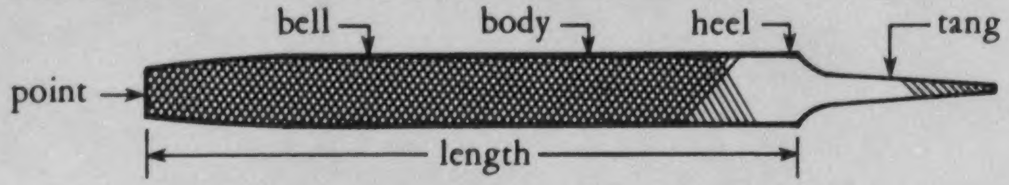


TWISTING

SQUARE STOCK

FLAT LONG STOCK

FILING COLD METAL


bell
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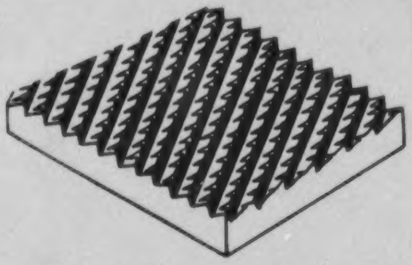
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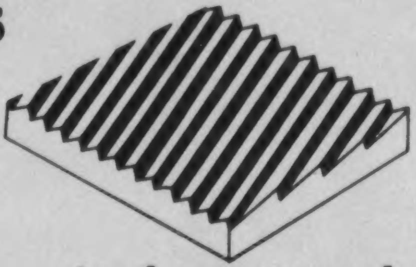
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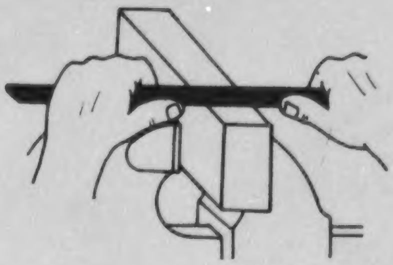

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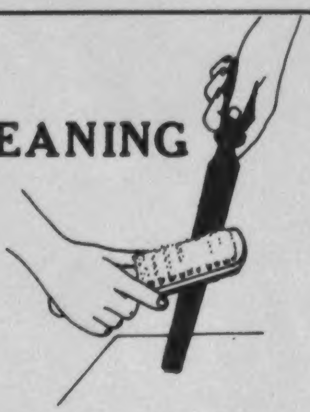

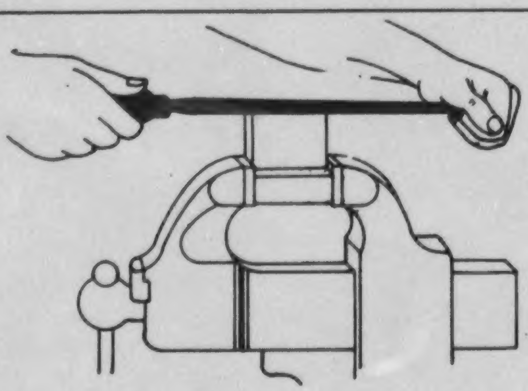
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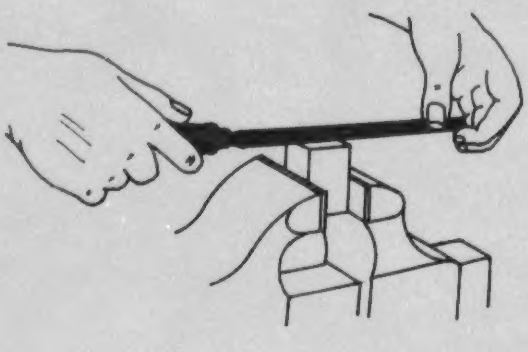

LIGHT FILING

GENERAL AGRICULTURAL MECHANICS

Unit M: Cold Metal Work

Topic 5: Identifying and Using Fasteners

Suggested Procedures and Activities: The use of different types of metal screws, machine screws, bolts, rivets, and washers as teaching aids can be very helpful during the class discussion.

1. Importance of Fastening Devices on Machines and Equipment

   a. Modern tractors and machines usually operate under heavy loads and in most cases under severe stress; therefore, fasteners (bolts, screws, nuts, rivets, pins, keys, and lock washers) are very important to the proper function of the machine.

   b. The purpose of fasteners is to hold the parts of the machine together under operating conditions. Each fastener is made for a specific purpose, and it should be used according to the machine specifications. Bolts and screws are usually found in larger numbers than other fasteners on a machine. Their purposes are:

      To give strength or permanency to metal parts or objects.
      To make the dismantling of a metal structure simple and easy.
      To fasten covers that conceal engine or motor parts that may need repairing occasionally.
      To make adjustments on machinery so that the machine will operate properly.
      To reduce the cost of cutting and welding machine parts on repair and inspection jobs.
      To simplify the manufacturing of machine parts. Certain assemblies and components must be made into several parts or pieces.

2. The Difference Between Bolts and Screws

   a. A bolt is usually thought of as a device used with a nut to fasten two parts together. A screw is usually thought of as a device for fastening two pieces together by passing through a hole in one and screwing into a tapped hole in the other, without the use of a nut. Bolts are usually sold with the nuts accompanying them, while screws are not provided with nuts.

b. The head (and nut) of a bolt is generally square or hexagon and is tightened by means of a wrench. The head of a screw is usually round in shape and is provided with a slot or some other means of tightening with a blade such as a screwdriver. (Exception: hex-head cap screw.)

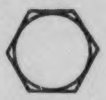
c. The sizes of bolts are usually given in fractional inch sizes, such as 1/4", 5/6", etc., while the sizes of screws may be in fractional inch sizes but are usually expressed in numbers from 0 to 30, to denote the gauge size of the steel wire from which the screws are made.

Transparency No. 1

3. Selecting and Using Bolts

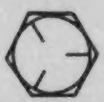
a. Bolts must have the same qualities as found in other materials. That is, they must be made of good metal, be long lasting, strong, corrosion resistant, reusable, temperature resistant, capable of withstanding vibration, and in most instances easy to remove. Bolts are classified according to grades by the Society of Automotive Engineers (SAE). The grades are determined by the material in a bolt and the treatments of the tensile strength (TS) (pull withstood by a bolt without breaking or being distorted). SAE markings (slashes) on the head of a bolt identify grade markings and strength. Examples are:

SAE grade 0,1,2



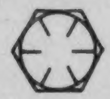
TS to 69,000 psi,min.

SAE grade 5



120,000 psi,min.

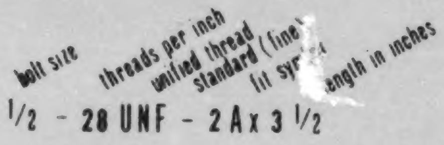
SAE grade 8



150,000 psi,min

b. There are several different types of bolt heads found in each class of bolts. Each type of head is especially made for a certain function. For example, a hexagon or square head bolt is used where the parts of a machine may be disassembled frequently. The round head carriage bolt is used mainly to attach metal to wood. The shoulder of the carriage bolt is pulled into the wood, and this prevents it from turning. A flat head carriage bolt is used in the same manner as the round head bolt, except that the head is flush with the surface. The large flat or tapered head carriage bolt (elevator bolt) is used in the same manner as the standard flathead bolt, but the head covers a larger surface. There are three different types of plow bolt heads. Each bolt is made for a specific purpose. All plow bolt heads are made to countersink into the metal, causing the head to be flush with the surface. These types of bolts are used to attach cutting blades on earth moving equipment and to attach plow shares to the moldboard. Hex socket head bolts are found on machinery where it is necessary to recess the head, and twelve-point head bolts are used where small heads are needed.

c. The size of a bolt is determined by the length and diameter of the body. Major diameter instead of minor diameter is used. The threads on a bolt are measured by the number of threads per inch, and major diameter is the measurement from the top of the threads (crest) on one side to the top of the threads on the other. Bolts may be described by using the following symbols:



Detailed description of the most commonly used bolts

Machine bolts may be used for heavy construction such as livestock feeders, gates, and trusses for buildings. The heads of machine bolts can be held with a wrench while being tightened. The size range is similar to a carriage bolt, about 1/2 to 1-1/4 inches in diameter, and the length is from 1 to 30 inches. They have either a square or hexagonal head and Unified National Coarse threads (UNC), UNF threads (Unified National Fine) or Unified National Extra Fine (UNEF).

Carriage bolts are generally considered the woodwork and wood-metal work type bolt due to the square shank under the round oval head. The square shank prevents the bolt from turning once it is set in the wood. The head cannot be held by a wrench; therefore, it may be difficult to remove; especially if the bolt is covered with rust. The length may range from about 1 inch to 20 inches. These bolts are threaded like machine bolts. These bolts are usually used on farm structures where metal is attached to wood.

Stove bolts are used for lighter work than are carriage bolts. They have round, oval, and flat slotted heads and may be loosened or tightened with a screwdriver. The stove bolt may be purchased with a Phillips head and in many sizes. The threads extend the full length of the bolt. The length of stove bolts ranges from 3/8 inch to 6 inches. These bolts are made with UNC threads.

Lag bolts are used with expansion shields to fasten wood and other materials to concrete, bricks, and stone. When a lag screw or bolt is inserted into a metal shield the shield expands in the hole as the square head of the bolt is turned clockwise with a wrench. This bolt does not have a nut. When attaching metal to wood or wood to wood it is necessary to drill two sizes of holes - one for the threaded part and one for the non-threaded part.

Stud bolts are used to fasten the cylinder head of an engine to the cylinder block. They are made so that one end can be attached by inserting in a prepared bolt hole, while the other end is free to accept a nut to draw the two pieces of metal together.

d. The use of bolts in joining metal together or joining metal with other materials is as follows:

(1) Center punch the top piece of metal at the point where the metal is marked (+) with a scratch awl.

(2) Select the proper size of twist drill to make a hole for the bolt. If the hole is too small, a long-tapered reamer may be used to enlarge it.

(3) Use the following methods to drill holes in pieces of metal that are to be joined together:

(a) Clamp one or more pieces of metal together and drill all aligned bolt holes at the same time.
(b) Mark the two pieces of metal separately and drill the holes separately; then place a bolt in the two drilled holes to hold the metal in a firm position for drilling the remaining holes.

(4) Draw the nut/s tightly when bolting metal together. Proper pressure on a nut will not damage the threads or stretch the bolt, but excessive twisting pressure will lengthen a bolt, deform the nut, and possibly cause the bolt to twist or turn in the hole. On the other hand, if the bolt is not properly tightened, it may work loose and may be sheared or cut by metal movement. These are some of the reasons why torque wrenches are used to tighten bolts on most machinery and why slotted and castle nuts are used with cotter pins.

(5) Secure bolts on vibrating machinery with lock washers fitted under the nut. When metal is attached to wood, flat washers may be used between the bolt head or nut and the wood surface. A wing nut is used where tightening pressure can be accomplished by the thumb and finger. Lock washers are usually not used with wing nuts.

(6) Use the proper size and type of wrench on bolt heads and nuts. For example, open end wrenches are used on either the square head or hexagon head bolts and nuts. Adjustable wrenches are also considered good square nut wrenches. A socket or box end wrench is thought of as a hexagon bolt wrench. Pipe wrenches and pliers are not made to use on square or hexagon bolts or nuts. Pipe wrenches can be used on pipe or round rods.

(7) Steps to consider when using a torque wrench to tighten bolts are as follows:

- (a) Make smooth steady pulls to prevent over-torqueing.
- (b) Before torqueing bolts, clean dirty holes, bolts, and nuts.
- (c) Damaged or blocked threads may give a false reading on the torque wrench.
- (d) Extra torque may be used to pass over these areas.
- (e) When tightening a bolt and a popping sound occurs, loosen the bolt or nut and retighten. Make a steady pull or turn with the wrench and at the same time take the torque reading.
- (f) Lubricate bolts and nuts or bolt holes very sparingly. A hydraulic lock may occur if a bolt hole contains too much oil.
- (g) Use torque tables when necessary. The table will give the outside diameter or body size and foot-pounds and inch-pounds tightening values of lubricated bolts and nuts.

Transparency No. 2

4. Selecting and Using Metal Screws

a. The two major types of metal screws are sheet-metal (self-tapping) and machine screws. Self-tapping screws are used on such materials as sheet metal, plywood, plastic, asbestos, and many other materials. These screws are an important type fastener used in agriculture machinery, farm metal buildings, heating and cooling installations, construction of ducts, and repair jobs where thin or sheet metal is involved. The use of these screws eliminates or reduces welding, riveting, and soldering.

Machine screws are used mainly in the construction of equipment and machinery. They are also used in building construction. For example, butt hinges and door closers are attached to metal jambs with machine screws. Certain types of lock cases are assembled with machine screws. The purpose of this type of screw is to assemble metal parts. They are used without nuts; therefore, the first part of metal has a bored hole for the screw, and the second part has a tapped hole that receives the threads.

b. Types of sheet metal screws are determined by the following characteristics:

(1) The different types of common screw heads.

Flat
Oval
Round
Binding
Pan
Blunt

The heads may be reed-prince, slotted, Phillips, frearson, clutch, or one-way.

(2) The gage numbers of sheet metal screws range from 0 to 24 and the length from 1/4 to 5 inches. However, the common length is up to 2 inches and the gage to 14. The following examples are used when identifying metal screws: a 1-1/4 inch number 10, flathead steel screw is written 1-1/4" No. 10 F. H. S., and the same screw in brass, but round head, is written 1-1/4" No. 10 R. H. B.

(3) Screws are made of steel, brass, bronze, and copper metals. Steel screws are used for ordinary work, and they are usually cheaper than alloy and copper screws. Brass and alloy-type screws are best suited for construction purposes where the screw is subjected to moisture. Copper screws are used with copper metals, giving the finished product an ornamental appearance. Screws are finished in many colors. They are: bright metal, blue, brass, bronze, and copper. They are also painted in various colors.

c. Machine screws are identified by the following characteristics:

(1) The types of screw heads

Flat
Oval
Round

Fillister
Hex

The head slots and shapes include slotted, fluted, Allen, clutch, Phillips, and hex.

(2) The gages of metal screws range from .060 (0) to 3/8 inch in diameter. This is the same gage measurement used for woodscrews except woodscrews exceed the 3/8 inch. The length may range from 1/8 to 3 inches. The screw gage number and length are used to make the selection. They are made with either UNC (Unified National Coarse) or UNF threads. The description may be written for a 1 inch long and 1/4 diameter screw with a flat head and fine thread as follows:

> 1/4" - 28 x 1" - F. H. S. The number 28 in this description is threads per inch. These screws are found in steel or brass.

d. The procedure for installing self-tapping screws is:

(1) Mark the hole location and prick punch tap lightly with a center punch.

(2) Either punch or drill the hole. Make the hole just slightly larger than

the root diameter excluding the threads. Hold the drill behind the screw to sight and compare screw diameter with the drill diameter. The surest method of determining or selecting the proper screw size is to use standard handbooks that give minor diameters of screws and hole sizes.

(3) Use a punch to align the holes. If the two pieces of material are loose, clamp them together before inserting the screw with a screwdriver. As the screw is driven into an untapped hole it cuts its own thread. Self-tapping screws can be found with pointed and blunt ends.

(4) If two pieces of metal are to be fastened together by using machine screws, drill the clearance hole slightly larger than the upper part or shank of the screw. A cap screw (a type of machine screw) is used where threads are required only in the second piece of metal. Locate and drill a second hole the right size. Tap this hole with the proper threads, and use a wrench or screwdriver, whichever is appropriate, on the screw head to draw the two pieces of metal together. This type of machine screw is made for heavier type fastening than is the ordinary screw.

Transparency No. 2

5. Types of Rivets and Their Uses

a. Rivets resemble certain types of bolts except that they have no threads. They are used to fasten two or more pieces of metal together. Rivets are used when it is not feasible to fasten metals by other methods. For example, if heat reduces the strength of a metal, rivets are used as fasteners. Light metal such as aluminum sheetmetal is usually riveted. This type of fastener is found in sizes from 1/4 to 3 inches long and from 1/8 to 3/8 inch in diameter. There are at least six different types of rivet heads. The most common types have round and flat heads. Rivets are selected by specifying the following: length, kind of head, diameter, and type of materials. The diameter of the rivet should be about 1/64 smaller than the diameter of the hole, and it should protrude through the last piece of metal about 1-1/2 times the thickness of the rivet diameter.

b. The common types of rivet heads and rivet body structure are:

Round, flat, countersunk, truss, cone, and steeple head shapes.
Tubular, split, solid, and blind are types of body structures.

c. The steps that may be used in riveting metal include:

(1) Mark (+) the center of rivet holes on the metal with an awl, and center punch the hole location.

(2) Use a twist drill the size of the rivet to make the hole.

(3) Countersink the hole if countersunk rivets are to be used.

(4) If the rivet is too long, cut it 1/16 to 1/8 inch above the metal surface. Before the rivet is cut, use a rivet set (hole over rivet) to draw the pieces of metal together.

(5) Make first few hammer blows straight down on the rivet to bulge the head. It may be necessary to peen the head that is formed from the shank or body of the rivet before using the rivet set.

(6) Use the rivet set to "buck" or shape the head solid against the metal.

(7) Set tubular and split rivets with special rivet sets. The tool (rivet set) is used to spread the sides of the rivet and draw the rivet edges down firm on the metal.

(8) Blind rivets are used where only one side of the joint is accessible. Most blind rivets have a hollow core for a pin. However, there is one type with an explosive core that spreads after it is seated in a hole. To fasten the drive-pin type of rivet, drive the pin to a depth to spread the rivet.

Transparency No. 3

6. Some Common Types of Washers and Their Uses

a. Plain washers are usually used with many different types of bolts in woodwork. It is necessary to use washers on both ends of machine bolts and round headed stove bolts if two pieces of wood are joined together. The head end of a carriage bolt may not require a washer due to its having a round flat head. Washers help make bolts and screws complete fasteners when tying wood or metal to concrete, metal, and wood. Plain washers are known as flat steel washers. They are usually larger than the head or nut of a bolt; therefore, washers of this type distribute the stress load over a wider area than is usually distributed by the bolt head and nut. The size of a washer is determined by its outside diameter and the diameter of the hole. When selecting a washer, the hole should be about 1/32 inch larger than the bolt or screw size.

b. Lock washers are used mainly to keep bolt nuts tight against a metal surface. Split-ring washers are used where vibration may cause the nut to loosen. They are made of spring steel and are cut with each end of the cut bent up to form tangs. The tangs bite into the nut or bolt head and the fastened part as the nut is tightened. The size of a washer is determined by the size of bolt; therefore, the hole diameter is expressed in bolt and not washer size. Washers that are smaller than 1/4 inch bolt size are identified by numbers that are used to identify machine screws.

c. Toothed lock washers are used in the same way as split-ring lock washers. The teeth (external, internal, or external-internal) are hardened and bent in such a way that they dig into the metal on the bolt nut and the surface of the fastened part. The most common types of these washers are the external (teeth on outside) and internal (teeth on inside). There is another type used less extensively, the external-internal (teeth on both outside and inside).

Transparency No. 3

7. Types of Nuts and Their Uses

a. There are many kinds of nuts used in agricultural work. The most common types used include the square, hexagon, and castellated. The square nut is commonly used for agricultural work, especially on wood or wood and metal projects. Hexagon nuts are not commonly used for woodwork unless metal is part of the construction. Castellated nuts are also seldom used on woodwork. This nut has an outward slotted lip. When used with a cotter pin, the nut is secured in place; therefore, it is used mainly on power machinery where vibration is a factor.

b. Common nuts are made of steel. Nut metal is usually softer than the metal in bolts. Many special nuts are made of alloy metals. The quality, dimensions, strength, and fit tolerances are regulated by the American National Standards Institute, the same as for bolts. Nut threads correspond to threads of bolts. The internal threads are fine or coarse. The dimensions of nuts include the inside diameter, thickness, and distance across flats (distance from one flat side to the other). Some common nuts are: square, hexagon, castellated, wing, speed, pal, cap, jam, self-lock, flanged, and spring.

Transparency No. 4

8. Removing Broken and Difficult to Remove Bolts

a. Many agricultural mechanics shops are not supplied with the various types and sizes of bolt extracting equipment that is necessary to remove any kind and size of bolt. Most bolts break at the surface of the hole, thus eliminating the use of any type of pliers or wrenches to extract the part left in the hole.

b. There are several methods used to remove broken bolts, and some of the most popular methods are:

(1) Screwdriver method is:

(a) Saw a slot across the broken stud bolt or cut a slot in the end with a cold chisel. It may be necessary to cut into the base metal to make the slot deep enough for a screwdriver.
(b) Back the broken bolt out by using the screwdriver.

(2) Punch and chisel method is:

(a) If the screwdriver method fails to remove the bolt, use a round nose punch or a flat chisel by placing the point in the slot on one side of the bolt.
(b) Tap the punch or chisel lightly to loosen the nut and finish removing it with a screwdriver or wrench. A large bolt (over 1 inch) and a small bolt (under 1/4 inch) should be removed by some other method.

(3) The extractor method is used when the other two methods have failed. An extractor ('Ezy-Out") is made of hardened steel with left-handed spirals. Steps to follow in using an extractor are:

(a) Dent the center of the broken bolt with a center punch.
(b) Drill a pilot hole in the center of the bolt, then follow the pilot drill with the size of drill that corresponds to the shank of the screw extractor.
(c) Insert the extractor into the hole and turn counterclockwise to loosen the broken bolt or stud. A tap wrench or adjustable wrench may be used on the fluted end of the extractor.

(4) Other methods used to remove bolts

A hole is drilled in the stud (broken bolt) in the same way as drilling a hole to insert a screw extractor, except that the hole may be larger in diameter and deeper. A diamond point chisel is tapped lightly into the hole and the stud is backed out by using an adjustable wrench on the chisel body.

A large hole is drilled in the stud by following the steps for drilling a hole to accommodate a screw extractor. The stud wall is left thin so that it may be pushed in with a chisel or punch. A flat instrument (screwdriver, etc.) may be used to force the stud out by turning it.

The broken bolt may be drilled completely out and the hole retapped for a larger bolt. If the broken bolt is large (over 1/2 an inch) the hole may be drilled with three different sizes of drills including the pilot twist drill, in order to make the drilling easier.

Heat causes metal to expand and cold causes it to shrink. Heat also causes rust and other foreign materials to break loose from the metal. After a broken bolt is heated and cooled it may be easier to remove with a screwdriver, punch, chisel, or extractor.

The use of the proper size striking wrench is considered a successful way to remove bolts.

Sizes of Drills and Extractors to Use

Twist Drill Inches	Size of Bolt Inches	Extractor Size No.
5/64	3/16 - 1/4	1
7/64	1/4 - 5/16	2
5/32	5/16 - 7/16	3
1/4	7/16 - 9/16	4
1-1/16	1-3/8 - 1-3/4	8
1-3/16	1-3/4 - 2-1/8	9
1-5/16	2-1/8 - 2-1/2	10
1-9/16	2-1/2 - 3	11

(5) General information to observe when removing broken bolts is:

Protruding broken bolts may be removed by welding nuts on them and backing them out with a wrench.

The use of penetrating oil may aid the extraction of broken studs, especially if the studs are rusty.

If the threads inside a hole have been damaged, it may be necessary to retap the hole before using it.

Screw extractors are easily broken if too much pressure is applied while backing out a broken stud. If an extractor breaks, it may be necessary to remove it with a cold chisel or punch by breaking it into small pieces.

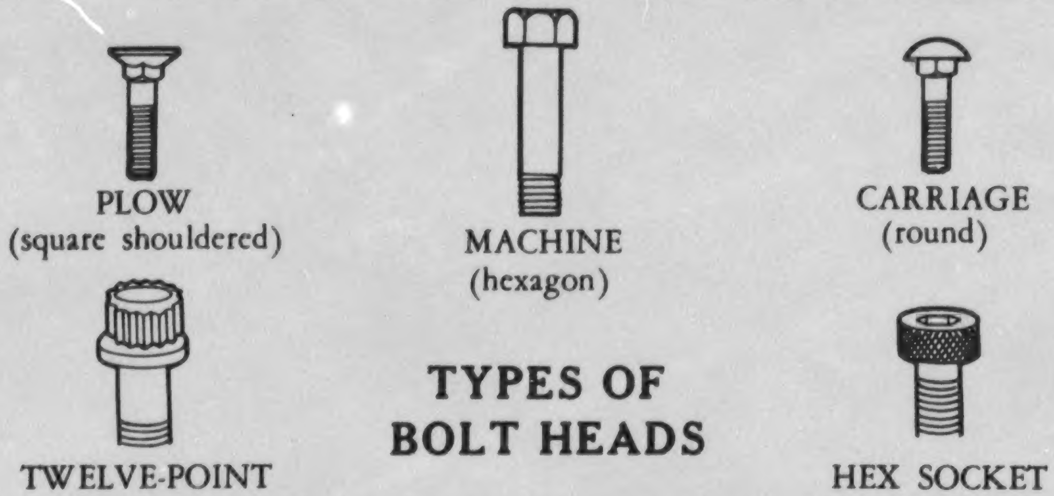
References:

1. Ludwig, Oswald A. and Willard J. McCarthy, Metalwork Technology and Practice, McKnight and McKnight Publishing Company, Bloomington, Illinois, 1969

2. Stockel, Martin W., Auto Service and Repair, The Goodheart-Willcox Company, Inc., South Holland, Illinois, 1969

3. "Fundamentals of Service, Fasteners", Deere and Company, Moline, Illinois, 1974

SELECTING BOLTS


PLOW
(square shouldered)

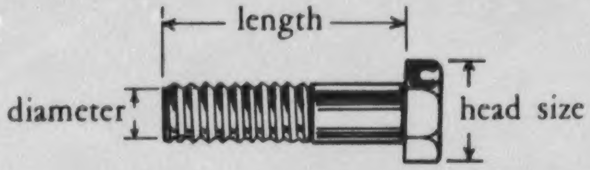
MACHINE
(hexagon)

CARRIAGE
(round)

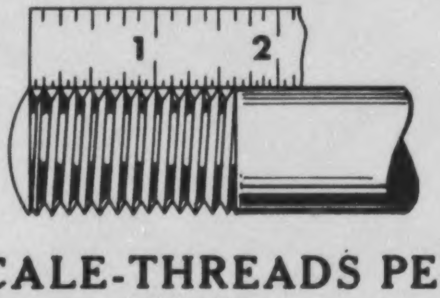
TWELVE-POINT

HEX SOCKET

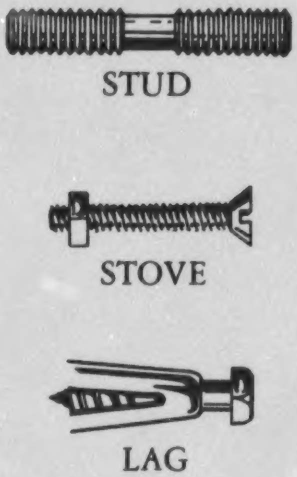
TYPES OF BOLT HEADS


length
diameter
head size

MACHINE BOLT



SCALE-THREADS PER INCH

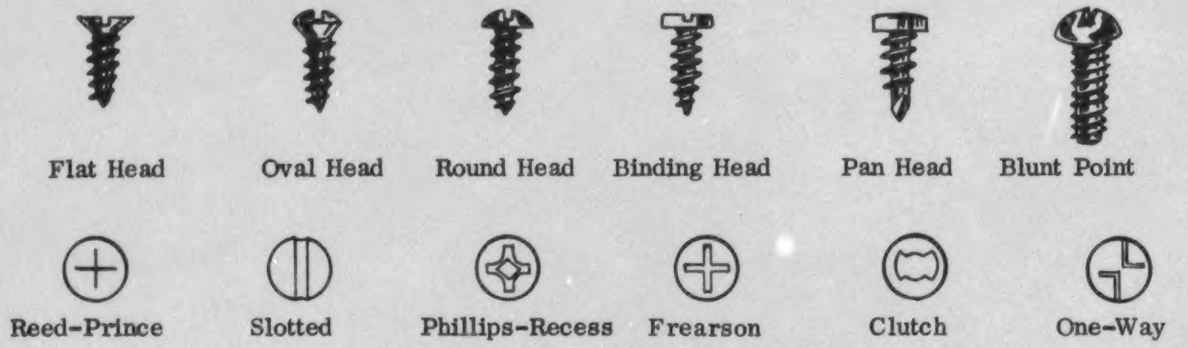

STUD

STOVE

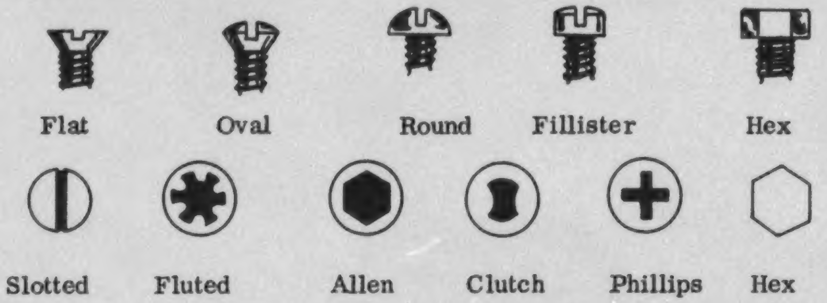
LAG

OTHER TYPE BOLTS

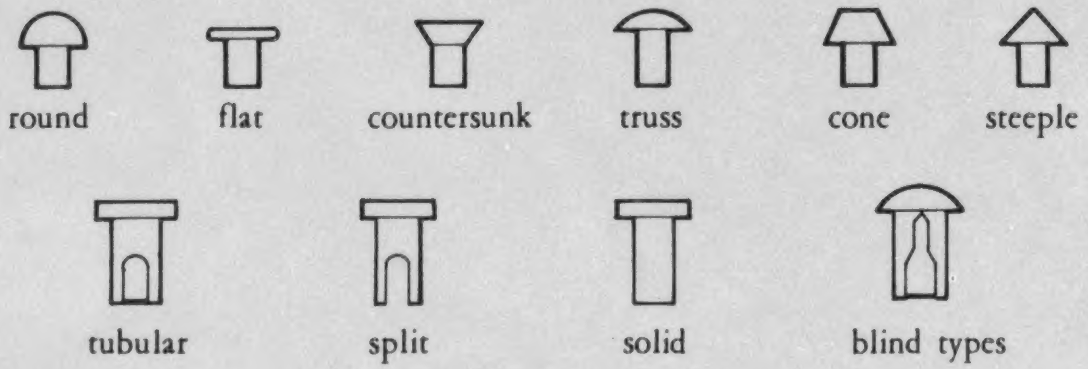
SCREWS & RIVETS


Flat Head
Oval Head
Round Head
Binding Head
Pan Head
Blunt Point
Reed-Prince
Slotted
Phillips-Recess
Frearson
Clutch
One-Way

SHEET METAL SCREWS


Flat
Oval
Round
Fillister
Hex
Slotted
Fluted
Allen
Clutch
Phillips
Hex

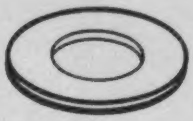
MACHINE SCREWS


round
flat
countersunk
truss
cone
steeple
tubular
split
solid
blind types

RIVETS

WASHERS & NUTS

WASHERS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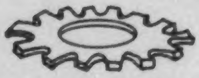
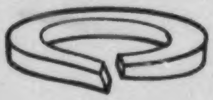
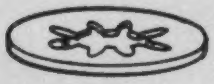
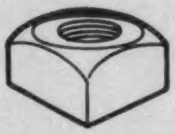
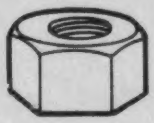

External Lock

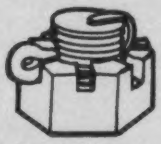

Lock

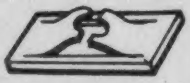

Internal Lock

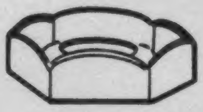
NUTS

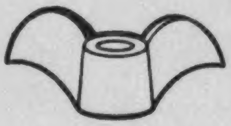

Square Nut

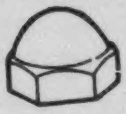

Hexagon Nut

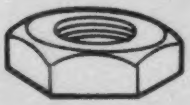

Castellated Nut & Cotter Pin

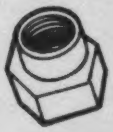

Speed Nut

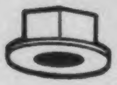

Pal Nut

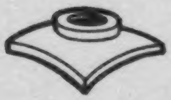

Wing Nut


Cap Nut


Jam Nut

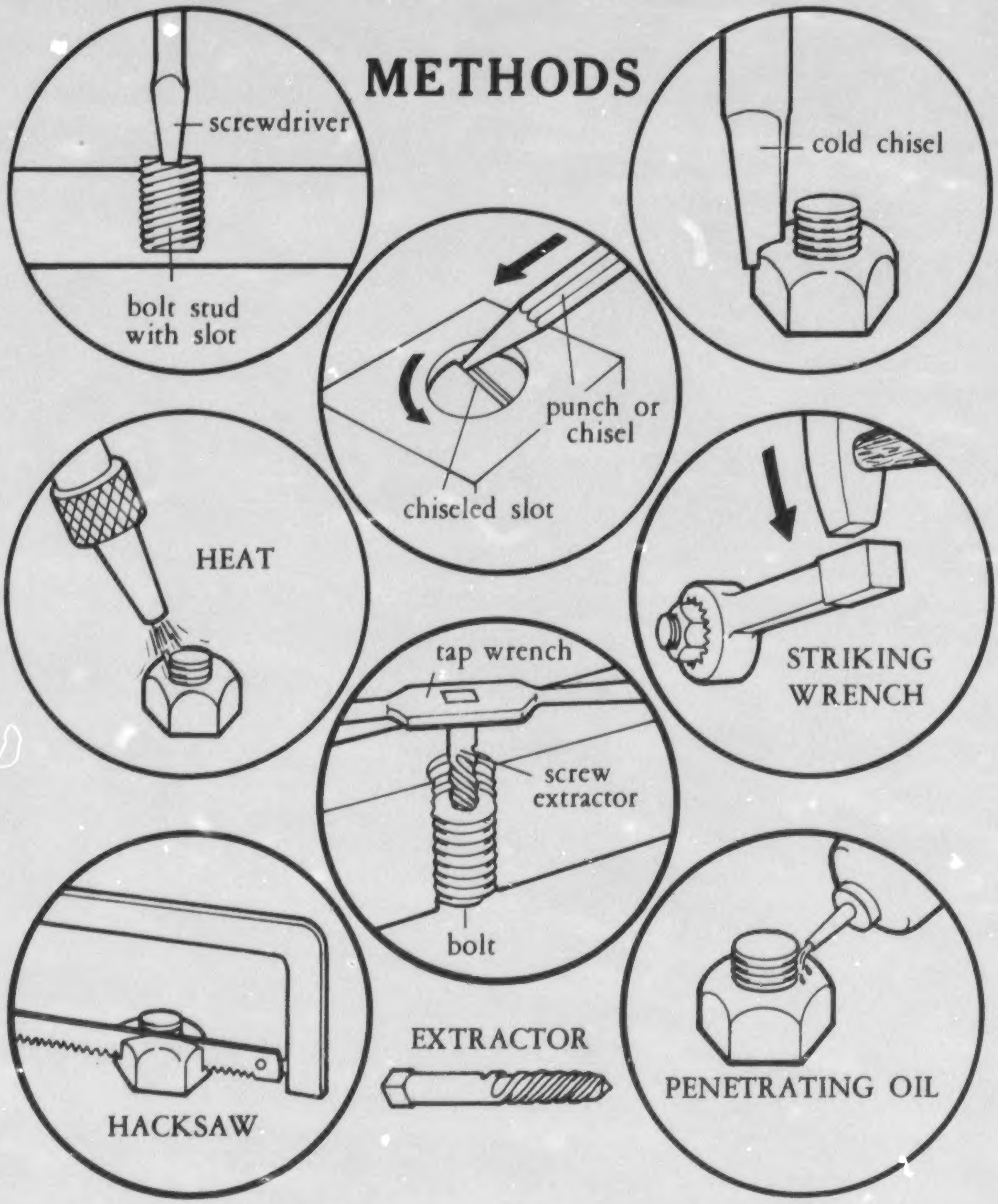

Self-Lock Nut


Flanged Nut


Spring Nut

REMOVING BOLTS

METHODS


screwdriver
bolt stud with slot
cold chisel
punch or chisel
chiseled slot
HEAT
STRIKING WRENCH
tap wrench
screw extractor
bolt
HACKSAW
EXTRACTOR
PENETRATING OIL

GENERAL AGRICULTURAL MECHANICS

Unit N: Soldering

Topic 1: Soldering Procedures, Equipment, and Materials

Note: Most of the information in this topic concerns the soldering of items of a general agricultural nature; however, some aspects of commercial soldering are included.

1. Introduction

Soldering is the process of joining two pieces of metal with the use of an alloy, which has a lower melting point than the pieces joined. Soldering should not be confused with fusion, the joining of two pieces of metal by melting. Solder penetrates the pores of metal and derives its strength from the penetration and the solder. Solder does not have the tensile strength (amount of pressure applied before a metal breaks) as that of a weld, and the tensile strength of solder will vary depending upon the solder used and the temperature at which it was applied.

Most solders are a mixture of tin and lead; however, traces of zinc, copper, aluminum, or other metals may be used in the mixture. The metals used and the proportion of each metal used in manufacturing solder affects the melting point of the solder. Pure tin melts or liquifies at 450 degrees F, while pure lead melts at 620 degrees F. Mixing the two in equal portions reduces the melting point to 400 degrees F. The more common solders are expressed as 40/60, 50/50, and 60/40. The first numbers always express the tin content.

A good all-around solder is the 40/60, while the plastic range of 50/50 solder is very narrow. The plastic range is the temperature range between when the solder begins to soften and when it becomes a liquid. The 60/40 solder has a narrow plastic range, a low melting point (361°F.), and is used to solder metals such as pewter.

Since tin readily dissolves and will form an alloy with most other metals, it can be mixed in any proportion with lead. Tin is an imported metal and is more expensive than lead, which is abundant in this country. For this reason, solders having a higher proportion of tin are more expensive.

Transparency No. 1

The forms in which solder is usually available are solid wire, core wire, bar, and ribbon. Wire and bar solders are the most popular, while ribbon is the least used. Bar solder may be purchased in sizes ranging from one-half to 1½ pounds. It is cheaper in the bar form; and if large amounts of solder are to be used, the bar form is recommended. Rosin and acid are the most popular types of core solders.

Solders are classified as soft and hard. For general soldering, soft solder is the one used. Hard solder, referred to as silver solder by many, requires a high temperature (from 1300 to 1460°F) and has more tensile strength. It is used in areas where the base metal is exposed to a high temperature and more strength is required. Hard solder is made by mixing silver with small amounts of brass, zinc, or copper. Usually, an oxy-acetylene or gas torch is used as the source of heat for hard soldering.

2. The Use of Fluxes with Solder

Fluxes are used with solder to clean the metal and prevent oxidization, the combining of metal with the oxygen in the air. The presence of oxide on the metal either causes the metal to reject the solder, or reduces the strength of the solder. Oxides may be present even though the metal appears clean.

Fluxes are classified as corrosive and noncorrosive and are available in paste, liquid, and powder forms. Corrosive fluxes must be removed by washing the area with water; otherwise, the flux residue will attract moisture in the atmosphere and cause a galvanic action. Corrosion due to galvanic action causes the metal near the solder to deteriorate.

Kinds and Uses of Fluxes

Fluxes	Uses
Corrosive Fluxes	
Hydrochloric acid (Known as muriatic acid)	Old galvanized iron, old zinc, and for cleaning metal
Zinc chloride (killed acid) (Prepared by dropping zinc into HCL until the reaction stops)	New galvanized iron, new zinc, copper, and brass
Powdered sal ammoniac	Black iron, steel
Noncorrosive Fluxes	
Rosin	Brass, copper, tin plate, pewter, (Especially for electrical wires)
Tallow	Lead

The method used to apply flux will depend upon the form used. Liquid forms of fluxes may be applied with a brush or plastic squirt bottle. Paste fluxes also may be applied with a brush. Powdered fluxes are sprinkled on the area to be soldered, or the point of the heated soldering copper may be placed in the flux and then placed on the metal to be soldered. One must be reminded, however, that the powder and paste forms of flux can be liquified if enough heat is applied to them.

3. Soldering Equipment

Transparency No. 2

Soldering Coppers

Soldering irons or coppers are used as the source of heat for most agricultural soldering. Both electric and non-electric coppers are used. The type and size to be used depends upon the amount of solder to be run, the metal to be soldered, the accessibility of electricity, location of the area to be soldered, and type of soldering to be performed.

Non-electric coppers range in sizes from one-half pound to several pounds. Three sizes of electric soldering irons are available: 100 watts, 200 watts, and 350 watts. Several different kinds of soldering guns are manufactured. They produce an intense heat at their tips and are used in inaccessible areas, areas having a flame hazard, or where intense heat is needed in a relatively small area.

The parts of the non-electric soldering copper are the handle, iron stem, bit or head, and tip. The bit is made from copper because it readily absorbs and transfers heat and is easily shaped and maintained. Wood is used for the handle because it absorbs very little heat and can be held without discomfort to the operator.

Sources of Heat

Transparency No. 3

The blow torch is used more than other sources of heat in agricultural soldering and for heating non-electric coppers. However, a bench type gas furnace and other sources may be used. Radiator shops and other commercial establishments use soldering torches heated with a mixture of some form of gas and oxygen. Plumbers often use the self-contained gas torch. Soldering coppers generally are not used when torches provide the source of heat.

Other Equipment

Transparency No. 4

Other equipment used in soldering will depend upon several factors. The following is a partial list of equipment used in addition to the equipment listed above:

Safety glasses (Goggles having at least a No. 4 lens should be worn if an oxy-acetylene torch is used.)
Gloves, acid resistant
Wire brushes (for cleaning metal and applying fluxes)
Glass, plastic, or crock containers with lids (Acid storage)
Tin snips
Files
Rviet sets
Electric drill and assorted bits
Table, asbestos top
Wood mallet (for shaping metal)
Center punch
Measuring and layout tools (Squares, calipers, marking gauge, etc.)

4. Tinning and Filing a Soldering Copper

A properly tinned soldering copper will hold solder on each of the sides that make up the tip. The copper must be tinned to apply the solder correctly. Through continued use, the copper will lose its tin, become corroded and pitted, and fail to transfer enough heat to the base metal.

Transparency No. 5

The first step in tinning the copper is to heat the copper to a dark cherry red, place in a vise, and file the tip until all pit marks, dross (scum), and scale have been removed and the sides of the tip are bright and smooth. If the copper does not need reforging steps two and three may be omitted.

In step No. 2, the copper is reheated, placed in a vise, and the misshapen tip is driven back into the body of the copper.

The copper is reheated in step No. 3, held on an anvil, and forged to the correct shape with a ball pein hammer.

In step No. 4, the copper is reheated to the normal soldering temperature (dark cherry red), rubbed on a block of sal ammoniac while solder is applied to the underside of the copper. The copper is rubbed on the block and in the solder until the tip will hold solder on all sides. Excess solder is removed by wiping the tip with a cotton cloth. Dipping the hot copper occasionally in a sal ammoniac solution will keep the tip bright and clean. The solution is made by dissolving one ounce of sal ammoniac in a quart of water.

Another method of tinning the copper is to heat the copper and rub it on a piece of tin on which solder has been placed.

5. Preparing the Surface for Soldering

The importance of preparing the surface to be soldered cannot be over emphasized. In order for the solder to penetrate the pores of the base metal, the metal must be clean. The procedure for cleaning base metal is as follows:

1. Metal is cleaned by grinding with a steel brush, or wire brush, or sanding with emery cloth or steel wool;
2. Muriatic acid is applied to the surface of the base metal to remove oxides;
3. Acid is removed by washing with water, and the metal is dried; and
4. Flux is applied if bar, ribbon, or solid wire solder is to be used.

6. Soldering Procedures

Using a Soldering Copper

Transparency No. 6

The maximum amount of heat is transferred to the base metal when the tip is in full contact with the metal. The solder--either solid wire, core wire, ribbon, or bar -- is applied to one of the edges of the copper making contact with the base metal, rather than the point of the iron. As the solder liquifies, the copper is moved along the seam or joint. The solder will flow rapidly if the copper is of the proper temperature and the copper is of adequate size.

The procedure for using a soldering copper is as follows:

1. Metal, seams, and/or joints are prepared;
2. Metal is cleaned thoroughly;
3. The soldering copper is heated (The use of two coppers will expedite the soldering; one copper is being heated while the other one is in use);
4. Flux is applied to the metal;
5. The heated copper is applied to the base metal;
6. Solder is applied to the copper;
7. Solder is run with the copper; and
8. After the solder has cooled, the flux is cleaned from the metal if a corrosive flux was used.

Soldering with a Torch

The two commonly used torches are the self-contained gas torch and the torch and tips. However, a limited amount of solder may be applied with a carbon arc torch.

The self-contained gas torch is particularly useful in "sweating" copper or other kinds of tubing. The strength of these joints is dependent upon the bond of the joint and not the amount of solder on the outer surface. The procedure for "sweating" a joint is as follows:

1. Tubing is cut to desired length;
2. Burrs and rough edges are removed from the tubing (both outside and inside);
3. The ends of the tubing and the inside of the joint are cleaned;
4. A thin coat of flux is applied to the inside of the fitting and to the area of the tubing that is to be placed inside the fitting;
5. The tubing is placed inside the fitting and is held against the shoulder of the fitting;
6. The fitting is uniformly heated on all sides;
7. Solder is applied until the joint is filled. (Because of capillary action, solder will flow throughout the joint if adequate heat has been applied);
8. Excess solder is removed from the joint with a cotton cloth, and the joint is allowed to cool; and
9. Joint is tested (for water tightness or other intended use).

Certain safety precautions should be followed when operating a torch and tips. These are listed below:

1. Fire extinguishers (CO_2) should be in the working area;
2. All combustible materials should be removed from the working area;
3. Gas and oxygen lines should be free of gases before lighting torch;
4. The operator should be dressed in protective outer garments (goggles, gloves, apron, fire retarding outer garments, etc.);
5. The working area should be well-ventilated;
6. Gas is lighted before opening oxygen valve;
7. Oxygen and gas valves are closed when soldering is completed; and
8. Never point torch toward someone else or yourself.

The following gives the step-by-step procedure for setting up a soldering torch having tips:

1. Foreign matter is removed from the insides of hoses by blowing them out;
2. Air hose is connected to oxygen regulator, which had previously been connected to oxygen storage tank;
3. Gas hose is connected to gas regulator, which had previously been connected to gas storage tank;
4. Valves on torch are closed, and hoses (oxygen and gas) are connected to torch;

5. Gas regulator is opened;
6. Oxygen regulator is opened;
7. Gas storage tank valve is opened;
8. Oxygen storage tank valve is opened;
9. Gas regulator is adjusted to correct pressure (one pound is sufficient for most jobs);
10. Oxygen regulator is adjusted to correct pressure (one pound is usually adequate);
11. All fittings are tested for leaks by using a sponge that has been saturated with soapy water. The sponge is used to apply the soapy water to the joints. Air bubbles may be observed at a leaking joint.

Below is listed the procedure to follow when using the torch to solder (it is assumed that the metal has been prepared for soldering):

1. With the torch being pointed away from the operator and others, the gas valve is opened one-eighth of a turn; and torch is ignited with a friction lighter;
2. Flame is adjusted to about three inches in length;
3. Oxygen valve is opened slowly until the flame tapers and turns blue (See transparency No. 6 for flame sizes.);
4. If bar, solid wire, or ribbon solder is used, flux is applied to the area to be soldered;
5. The base metal is heated (The outer one-fourth of flame is applied to the base metal);
6. Solder is applied to the heated metal;
7. When soldering is completed, the gas valve on torch is closed. (This valve is always closed first);
8. Air valve is closed on torch;
9. Valve on gas storage tank is closed;
10. Valve on oxygen storage tank is closed;
11. Gas and oxygen valves on torch are opened;
12. Pressure is released on gas and air regulators;
13. Valves on torch are closed; and
14. Flux is cleaned from metal if a corrosive flux was used.

The carbon arc torch is attached to the ground and electrode holder of an arc welder. It is capable of producing a flame with a heat intensity of 9,000 degrees F. The size of carbon rods used on the torch depends upon the amount of heat required, thickness of metal, and kind of metal.

Size of Carbon	Welder Amperage	Metal Thickness
1/4 inch	20-50	up to 1/40 inch thick
5/16 inch	30-70	1/40 to 1/20 inch thick

The carbons used for a torch connected to an A.C. welder should be the same size, while the carbon on the cable connected to the electrode holder on a D.C. welder should be one size larger.

The carbon tips are extended about two inches below the carbon holders on the carbon arc torch and should form a vee. The arc is started by moving the carbons toward each other. After the flame has started, the carbons are adjusted to about 3/16 of an inch apart. The same soldering procedure is followed with the carbon arc torch as is used with other torches.

7. Some Joints Used in Joining Soldered Metals

Several different kinds are used in joining metal to be soldered. The joint used will depend upon the item to be soldered, kind of metal, strength required, location in which item will be used, and preference of worker.

Transparency No. 7

If possible, interlocking joints or other similar types of joints should be used when joining sheet metal, but this is not always possible or practical. However, in most cases joints can be reinforced with solder. One method of reinforcing butt joints is to solder on both sides of the joint. Another method is to place two pieces of masking tape parallel to the edges to be joined and about half the width of the bead from each edge. The tape prevents the molten solder from spreading and allows more solder to be placed on the joint. Flux and solder are applied between the strips of tape on both sides of the metal.

Soldering on each side of a lap joint also will reinforce the joint. The use of a strip of metal on the underside of a butt joint is still another means of reinforcing a joint. The use of a sleeve made from tubing and a metal collar are used to reinforce tubing and bars.

Transparency No. 8

In the above transparency are illustrations of riveting, "sweating" two pieces of metal, and soldering around rivets to make the joint water tight.

To "sweat" two pieces of metal, each piece is tinned where the two pieces are to be joined, the pieces are placed together, and heat is applied until the tinned covering on the metal melts.

The procedure for soldering riveted seams is as follows. (This is after the metal has been cleaned.):

1. Drops of solder are placed at intervals along the edge of the seam;
2. A flat side of the heated soldering copper is placed on the seam until the solder melts and flows into the seam and around the rivet; and
3. The soldering copper is moved slowly along the seam until all drops of solder are melted and has flowed into the joint and around the rivets.

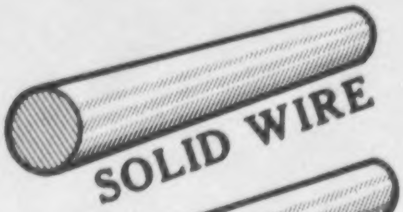
References:

1. Phipps, Lloyd J., Mechanics in Agriculture, The Interstate Printers and Publishers, Inc., Danville, Illinois, 1967

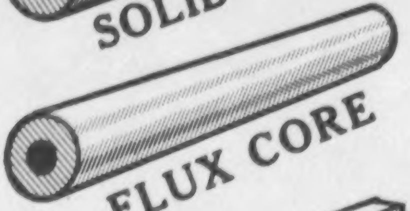
2. Walker, John R., Modern Metalworking, The Goodheart-Willcox Company, Inc., South Holland, Illinois, 1968

3. Horowitz, Harry, Auto Radiator Repair and The Cooling System, Mc Graw-Hill Book Company, New York, New York, 1972

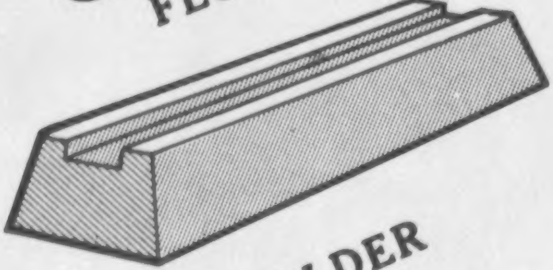
SOLDER FORMS



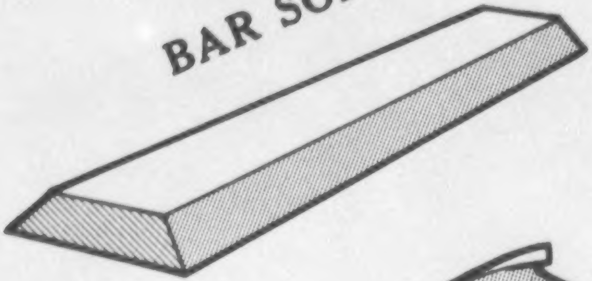
SOLID WIRE

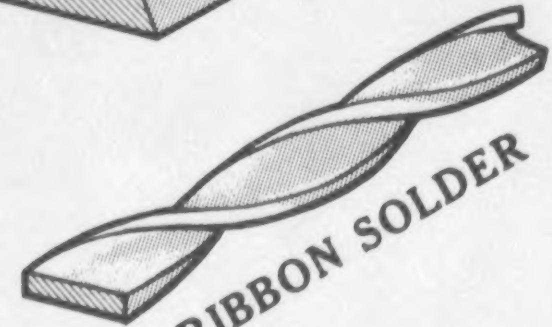


FLUX CORE

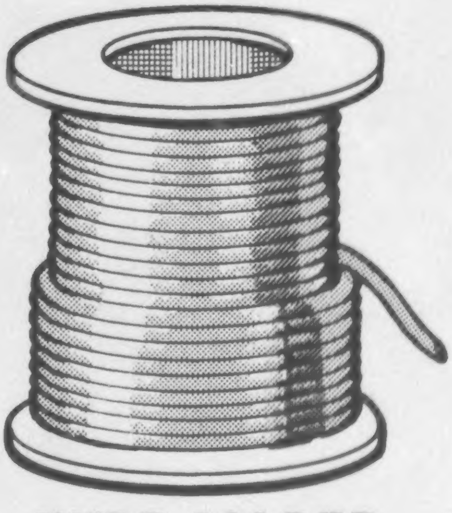


BAR SOLDER



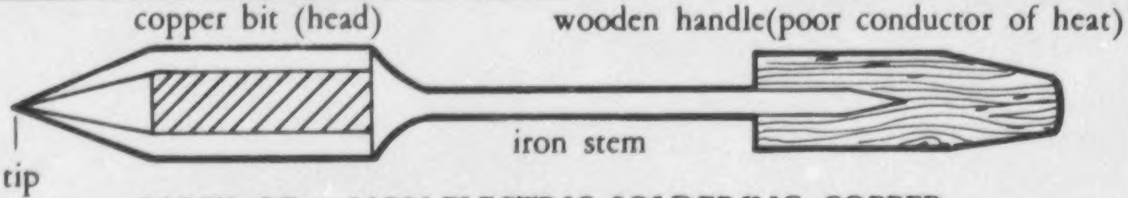


RIBBON SOLDER



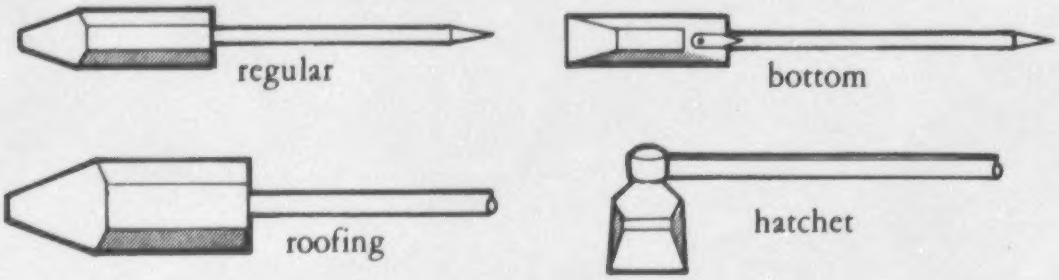
WIRE SOLDER

SOLDERING COPPERS (IRONS)

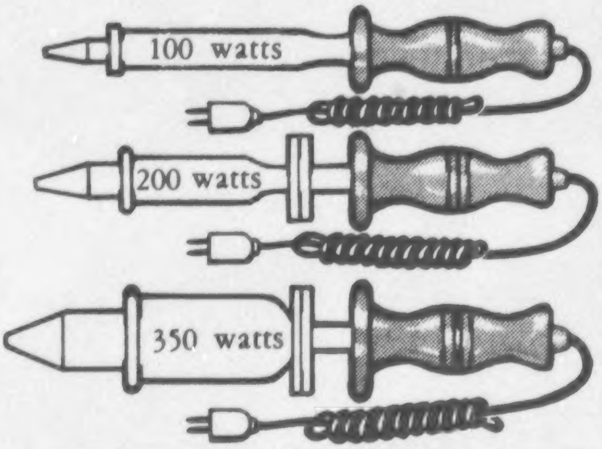

copper bit (head)
wooden handle(poor conductor of heat)
tip
iron stem

PARTS OF A NON-ELECTRIC SOLDERING COPPER

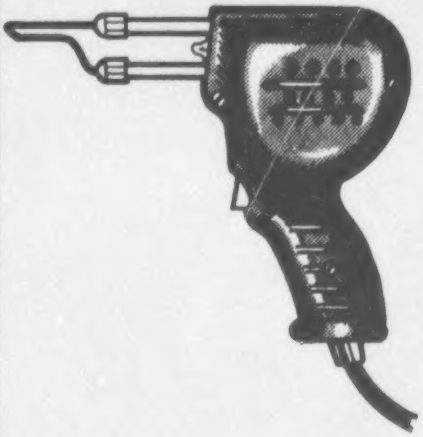
NON-ELECTRIC COPPERS


regular
bottom
roofing
hatchet

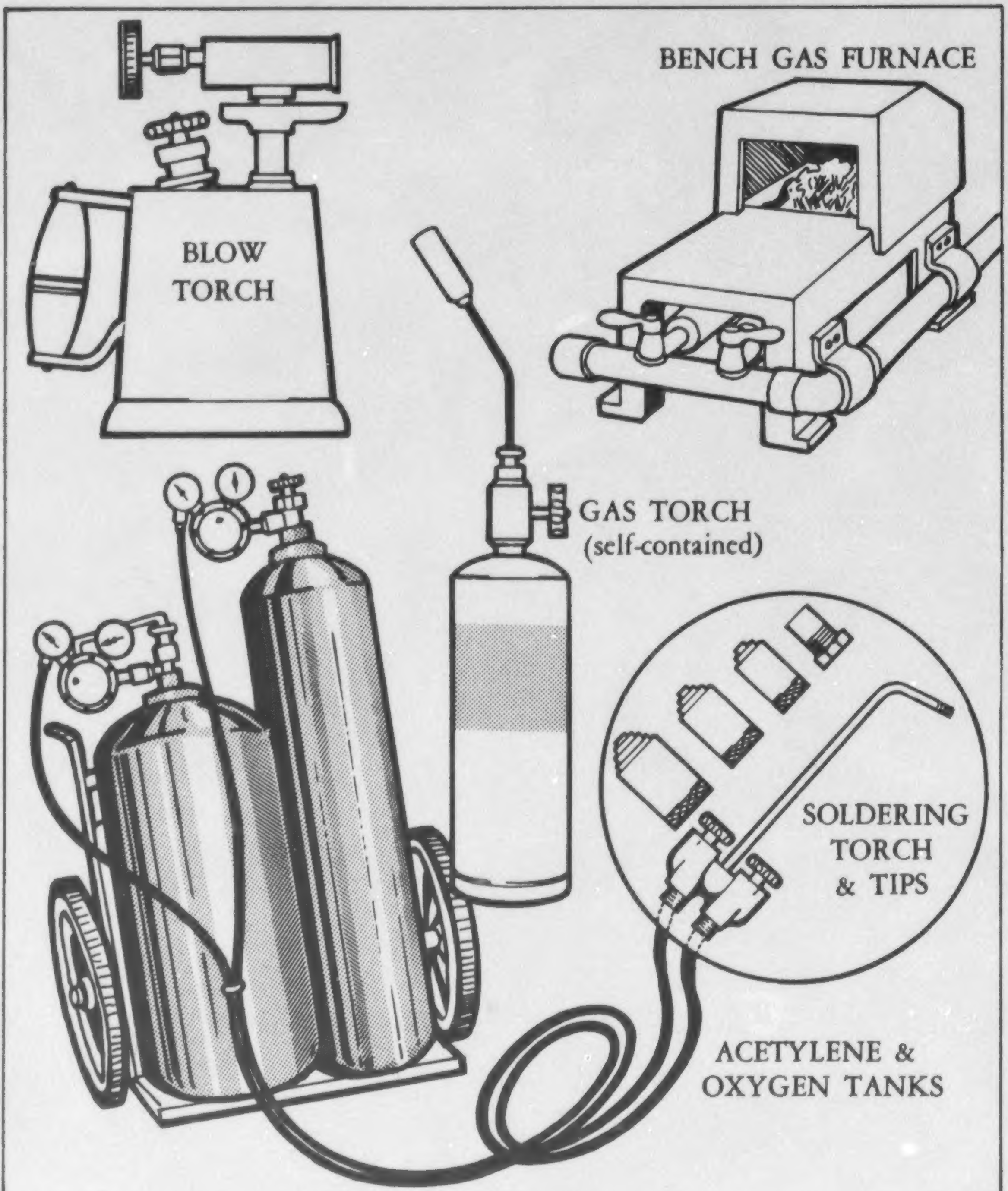
ELECTRIC SOLDERING COPPERS


100 watts
200 watts
350 watts

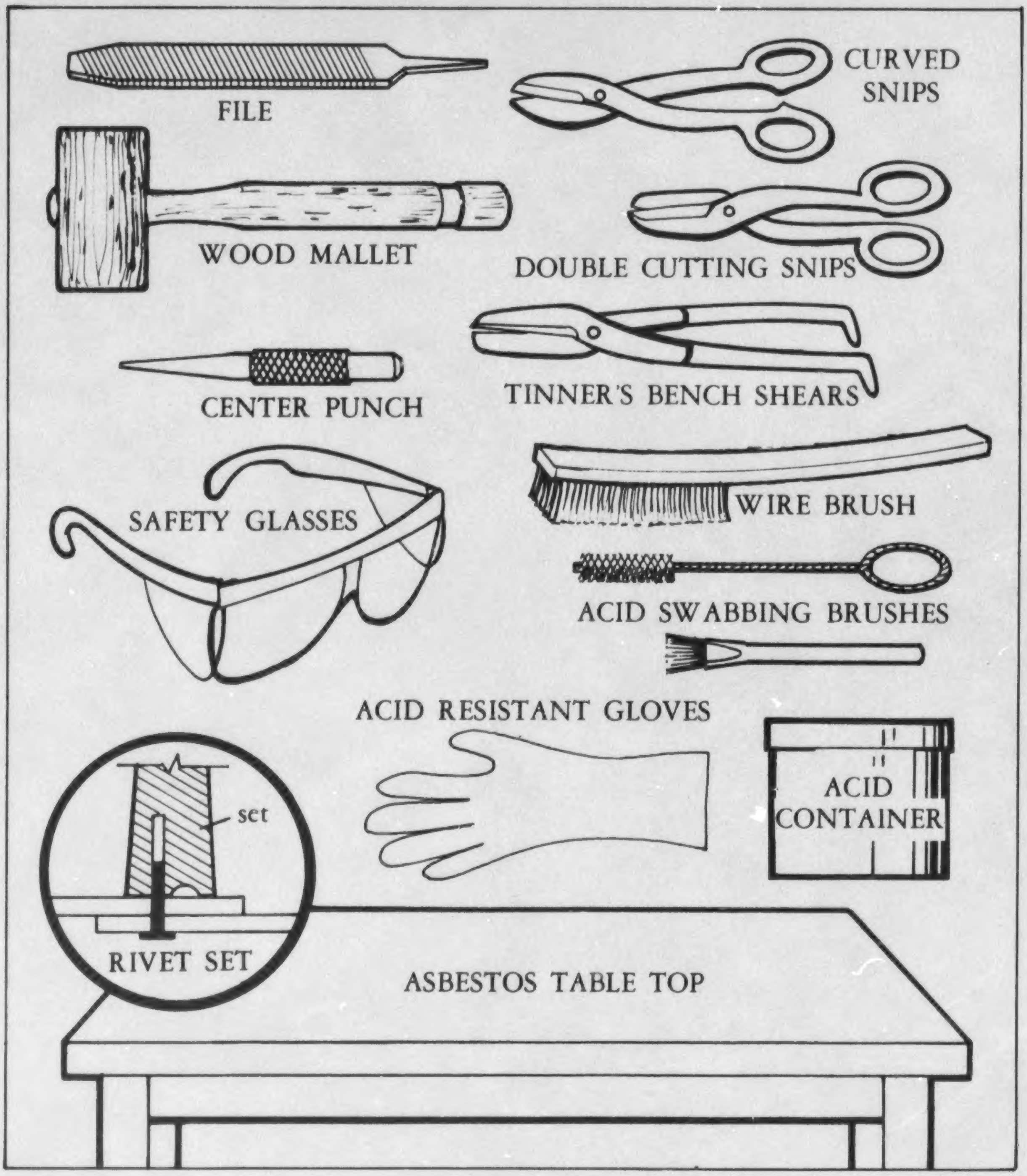
SOLDERING GUN



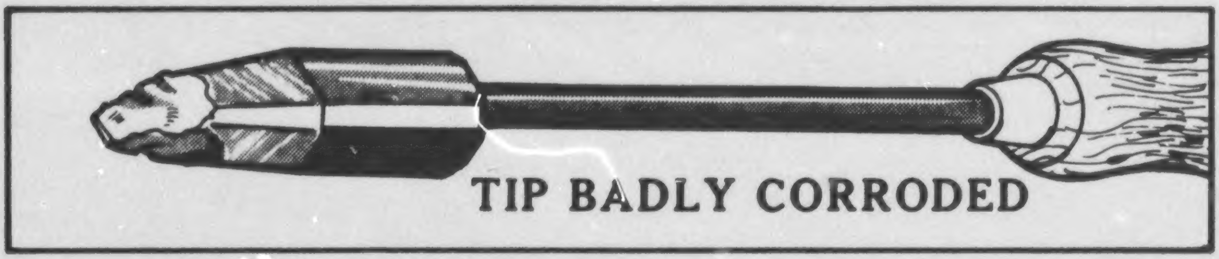
SOLDERING IRON HEATING EQUIPMENT

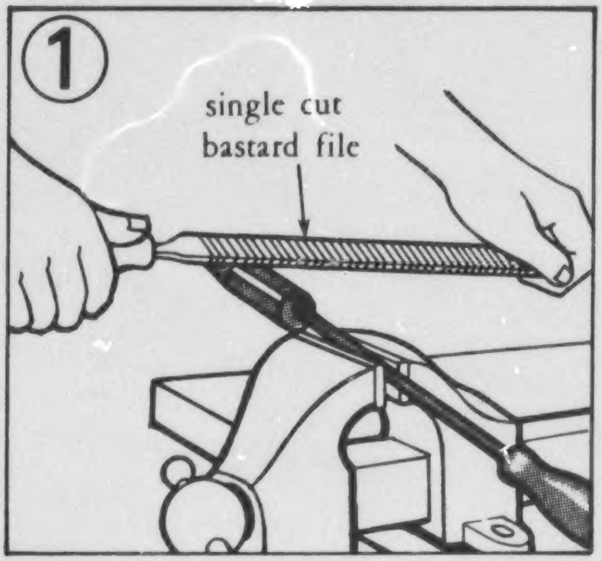

BENCH GAS FURNACE
BLOW TORCH
GAS TORCH (self-contained)
SOLDERING TORCH & TIPS
ACETYLENE & OXYGEN TANKS

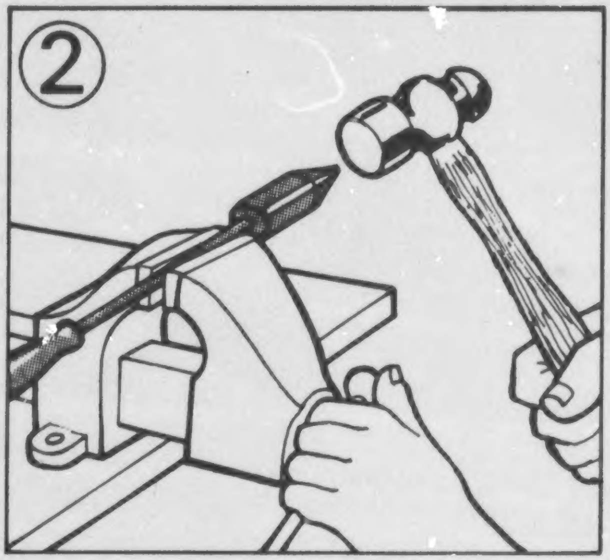
SOLDERING EQUIPMENT

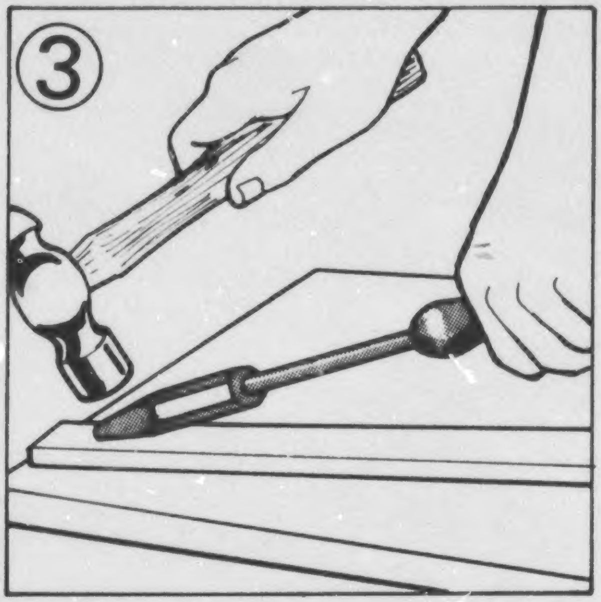

FILE
CURVED SNIPS
WOOD MALLET
DOUBLE CUTTING SNIPS
CENTER PUNCH
TINNER'S BENCH SHEARS
SAFETY GLASSES
WIRE BRUSH
ACID SWABBING BRUSHES
ACID RESISTANT GLOVES
ACID CONTAINER
set
RIVET SET
ASBESTOS TABLE TOP

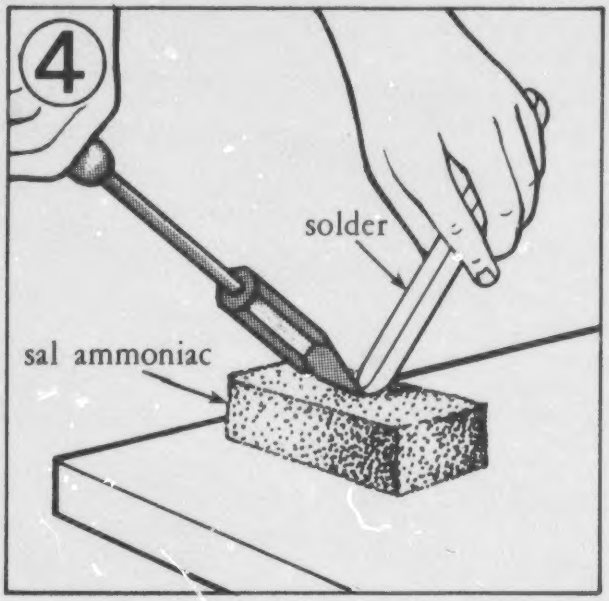
TINNING A SOLDERING COPPER


TIP BADLY CORRODED

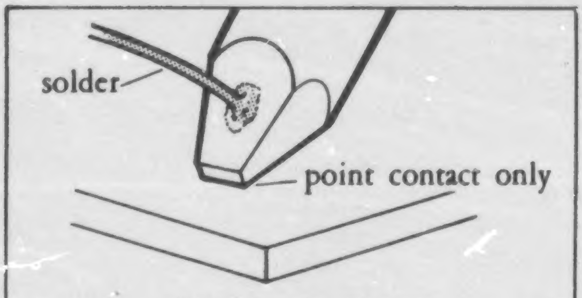

①
single cut
bastard file



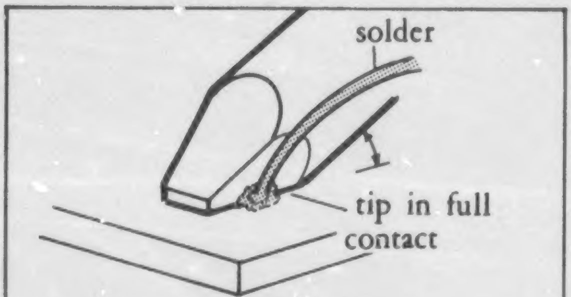



④
solder
sal ammoniac

HOLDING IRON & APPLYING SOLDER

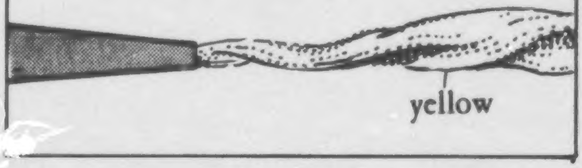

solder
point contact only

INCORRECT

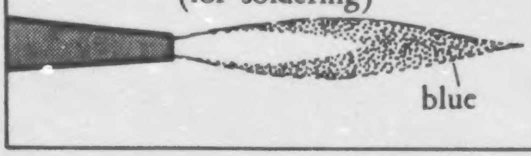

solder
tip in full contact

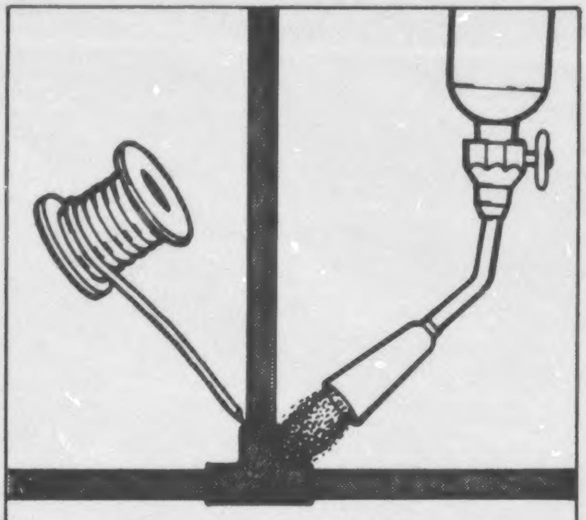
CORRECT

GAS FLAME WITHOUT OXYGEN

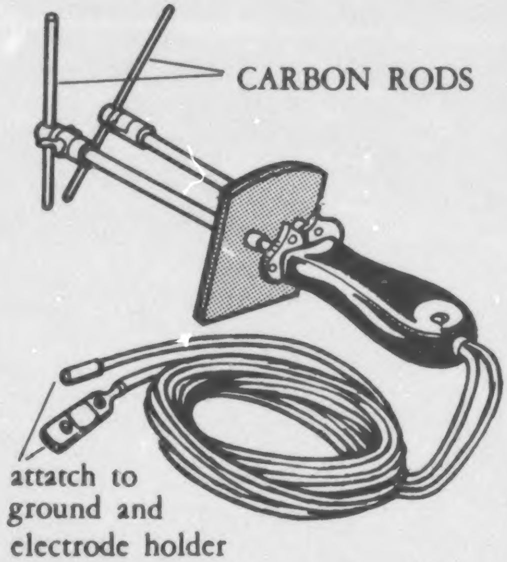


GAS FLAME WITH OXYGEN
(for soldering)



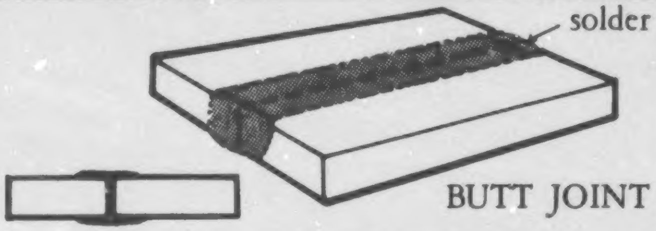


GAS TORCH
(for bonding joints)

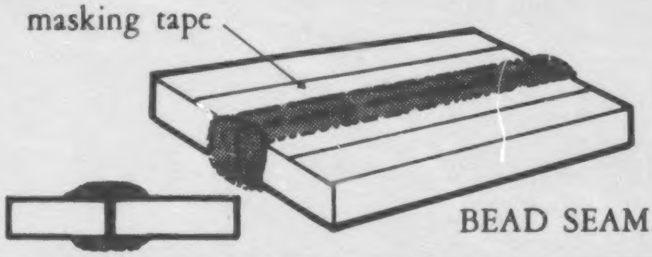

CARBON RODS
attatch to
ground and
electrode holder

CARBON ARC TORCH

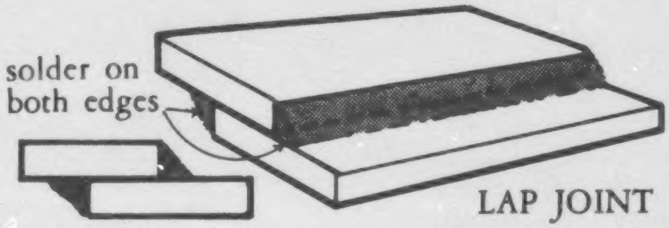
JOINING SOLDERED METAL



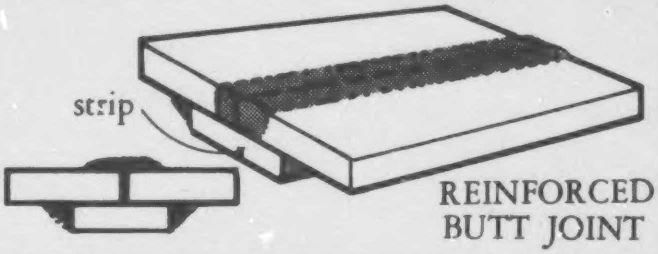
BUTT JOINT


masking tape

BEAD SEAM


solder on
both edges

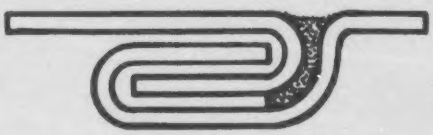
LAP JOINT



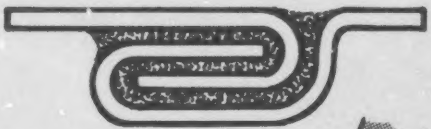
REINFORCED BUTT JOINT

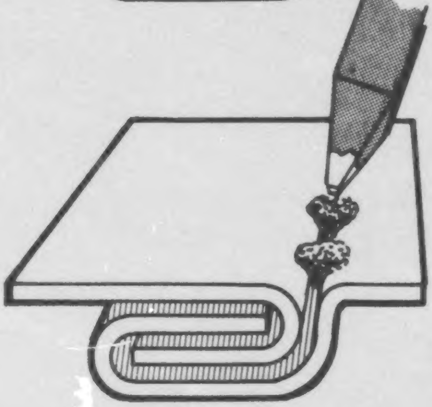
INTERLOCKING JOINTS

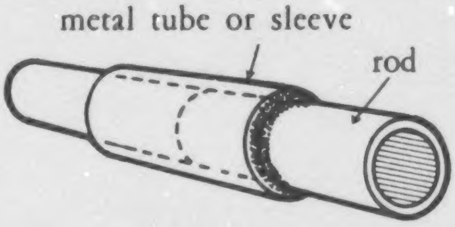
POORLY SOLDERED

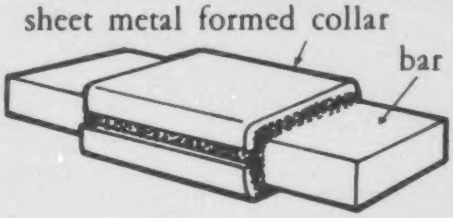


PROPERLY SOLDERED

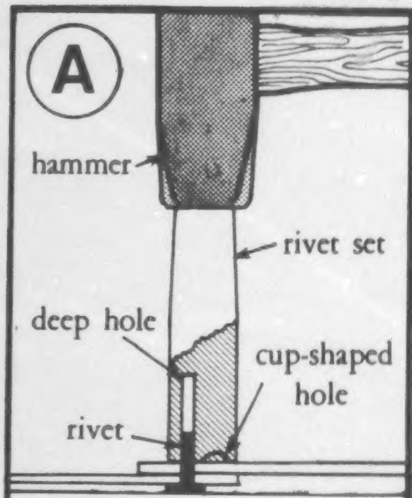




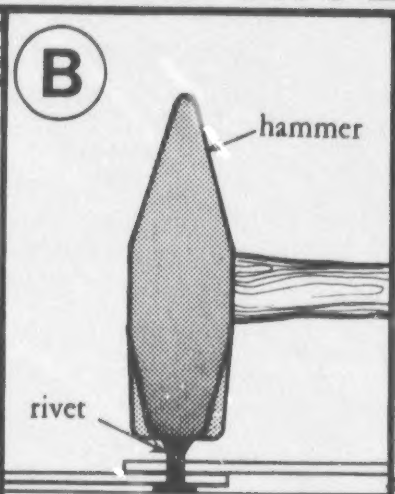

metal tube or sleeve
rod


sheet metal formed collar
bar

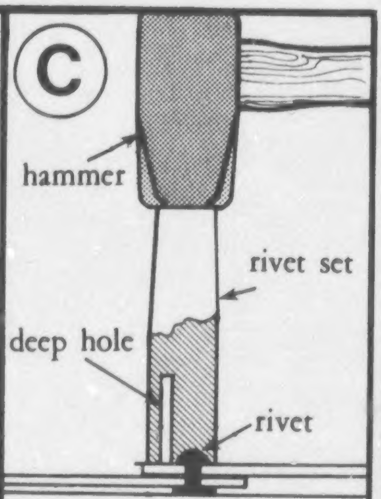
RIVETING THIN SHEETS OF METAL AND SOLDERING AROUND RIVET


A
hammer
rivet set
deep hole
cup-shaped hole
rivet

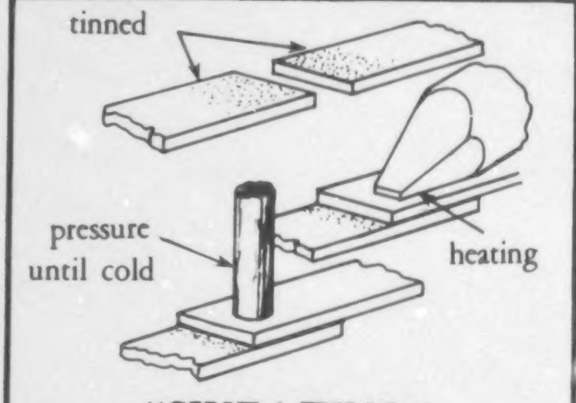
DRAW SHEET METAL TOGETHER


B
hammer
rivet

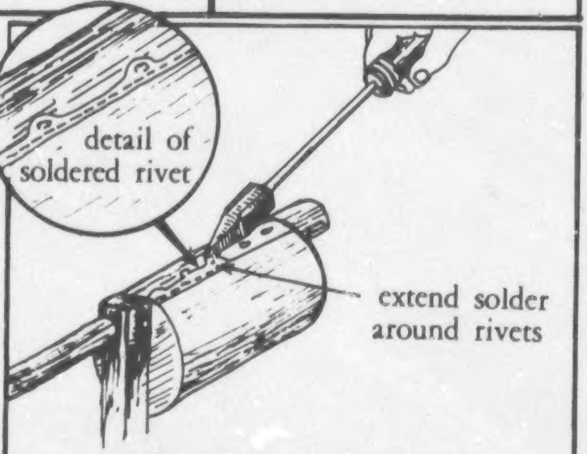
TIGHTEN RIVET WITH HAMMER


C
hammer
rivet set
deep hole
rivet

FORM HEAD


tinned
pressure until cold
heating

"SWEATING" TWO PIECES OF METAL TOGETHER


detail of soldered rivet
extend solder around rivets

SOLDERING AROUND RIVETS

GENERAL AGRICULTURAL MECHANICS

Unit O: Planning An Agriculture Safety Program

Topic 1: Operating Tractors and Other Machines Safely

Suggested Procedures and Activities: After the class discussion a tractor and other farm machines and equipment may be used as exhibits to point out safety and non-safety features.

1. Importance of Practicing Safety

Most accidents are caused by carelessness on the part of the individual operator. Surveys on what causes accidents resulted in the following information: eighty to 85 percent of all accidents are caused by human error or carelessness, 10 percent are caused by faulty equipment, and 2 to 4 percent are caused by unavoidable happenings (lightning and other causes). Someone made this statement, "Most accidents don't just happen, they are caused by human error". Such general things as failing to study and follow instructions in the machine operator's manual, working when greatly fatigued or ill, or failing to keep the machine in a good operating condition and to correct hazards that may cause accidents can all be classed as human error.

There are about 2,000,000 disabling injuries caused by accidents in the U. S. each year in the major industries, and about 290,000 of these injuries are in the agricultural industry. Agricultural machinery is the major source of all recorded farm accidents.

Everyone hopes to live a life free of accidents and illness. A permanent injury may cause the reduction in earning power and lower the family standard of living. Many injured individuals experience going through a retraining program that is time consuming and expensive.

In order not to be "accident prone", the individual must become safety conscious if safety habits are to be developed. If something is being done dangerously, a positive safety attitude may prevent an accident. Such an attitude will change the method to a safer way.

Transparency No. 1

2. Operating the Tractor Safely

a. A tractor is similar to any other moving vehicle, in two ways; it is not dangerous when operated properly, and it has a center of gravity. The weight of the wheel tractor is concentrated in front of the rear axle and midway between the rear wheels. The tractor will not likely tip over on a slope until the center of gravity is outside the rear tire, unless it is turning. The centrifugal force on a tractor making a turn is outward; therefore, a tractor may tip over on the side while making a turn at a high speed. A tractor may be upset at eight miles per hour on level ground.

b. Safety rules to observe are as follows:

(1) Use the drawbar to pull a heavy load. The tractor may tilt backwards if the axle or seat bracket is used.

(2) Drive the tractor at a moderate speed. Many tractor upsets are caused by high speeds to and from work.

(3) Drive the tractor across ditches that have gradual slopes. The tractor may tilt backwards or sideways if driven into ditches with steep banks.

(4) Drive at a slow tractor speed in tall grasses or weeds. A hidden rock, stump or log can cause the driver to fall off the tractor or might make a sudden turn.

(5) Avoid driving along a steep slope. A small hole, bump or turn may cause the tractor to tilt sideways. Use the engine to help brake the tractor.

(6) Use the tractor for only those jobs it's designed to do. Running errands and playing cowboy may cause a serious accident.

(7) Drive with utmost care in mud and on slippery ground. Wheels stuck in the mud can cause an accident. The chassis may revolve around the axle when power is applied.

(8) Work on attached equipment with the engine stopped, the tractor out of gear, and the brakes engaged. Such precautions may prevent an accident from occurring when hitching or working on attached equipment standing on a slope.

(9) Use rear wheel weights when using a front end loader on a tricycle tractor to avoid having the tractor tip forward.

(10) Consider the tractor as a one-rider vehicle. The operator should be the only person on the tractor when it is in operation.

(11) Avoid heavy and high speed traffic. It pays to haul the tractor rather than have it exposed to traffic conditions. Any slow-moving vehicle should use the slow-moving symbol day and night when traveling on roads or highways.

About 2/3 of all slow moving vehicles that are in collisions are hit from the rear by fast moving vehicles.

c. Other safety rules to observe are:

(1) Always start the tractor in neutral gear.

(2) Stop the engine and do not smoke when refueling the tractor.

(3) Never ride on the drawbar or dismount the tractor while it is still moving.

(4) Do not leave the engine running if the tractor is unattended.

(5) Wear snug fitting clothing when working around or on the tractor.

(6) Service the tractor with the engine stopped.

(7) Wait for a very hot engine to cool before adding water to the radiator.

(8) Ground the engine when doing belt work. The belt pulley should be motionless before putting on or removing the belt.

(9) Operate the tractor at night only if it is equipped with adequate lights and other warning equipment.

(10) Be sure that all safety and protection shields for moving parts and electrical wiring remain in place.

(11) Reduce speed and keep the tractor in gear when going down steep slopes or hills.

Most tractor and equipment accidents are caused by the operator failing to recognize the approaching danger or by the operator's carelessness. Accidents may be reduced or eliminated completely if the operator observes the safety rules for operating a tractor.

The best time to form correct and safe operating habits is when the operator is learning to operate the machine. Usually the operator's manual is studied at this time. The manual warns against unsafe habits and explains how the operator may develop safe practices.

Each year new safety devices are designed and placed on the tractor and tractor equipment. These safety devices are designed to protect the operator and others. If they are removed or made inoperable, the chance of being injured becomes greater. Actually, the best type of safety device is the operator.

3. Driving the Tractor

a. Starting the Movement - The foot brakes must be unlatched before the tractor is put in motion. There are several different types of latch releases. Some of the most common are: Pull rod, lever and toetrip. Some tractors have both brakes on one side, whereas, others have a brake on each side of the engine. The PTO must be disengaged before starting the engine.

Idle the engine before engaging the clutch and shifting gears.

Disengage the clutch so that all power will be removed from the transmission, thus stopping the gears from rotating.

Shift the gear to the desired speed and engage the clutch. The rate of engine speed (quickness) for engaging the clutch will depend on the type and condition of tractor and the position the tractor is in at the time of movement. Clutches grab on some tractors, causing a sudden lunge forward. Engage the clutch easily.

A power shift can be shifted with the tractor in motion or on-the-go. The change in gear ratio is by a system of brakes and clutches that function together by hydraulic pressure. Change the gears one at a time.

If the tractor is equipped with a hand-shift transmission, the gears should not be shifted while the tractor is in motion. Some tractors are equipped with "gearshift stations"; therefore, gears can be changed in the station while the tractor is in motion. The clutch disc and the transmission shaft must be stopped completely on most hand-shift tractors in order to avoid gear damage.

The tractor steering system is similar to an automobile. On most farm tractors a steering wheel is used to guide the front wheels. However, a tractor is equipped with individual brakes to assist the steering. A short turn may be made by braking one wheel.

b. Stopping the Movement - Retard the throttle to reduce the engine speed. Press down firmly on the clutch pedal to disengage the clutch. Shift the gear to the neutral position. The brakes may aid in bringing the tractor to a complete stop. The brakes are locked by pressing the brake pedal down. The speed-control lever should be set at fast idle if the engine is left running. If the driver is to dismount from the tractor, the engine must be stopped.

Transparency No. 2

4. Special Safety Practices to Observe When Operating Tractors and Other Machines

a. Many accidents are caused by the power takeoff (PTO). The most common accident is getting caught by the PTO shaft or rotating machine shaft. On some occasions an attached shaft will break or become disconnected and begin swinging dangerously behind the tractor.

b. Safety practices used to eliminate PTO accidents are:

(1) Master shields are used on tractors to protect the operator and others from coming in contact with the short PTO shaft. In order to completely eliminate the danger of coming in contact with the PTO shaft, a tubular guard shaft must be used over the stub shaft.

(2) Tunnel shields are used on the equipment shaft. This shield must extend from the equipment to the stub shaft of the tractor. Such shields may be nothing more than metal or other hard material guards. Some shields completely surround the shaft, whereas others are U-shaped covers supported by braces. Many of the integral-journal (tube) shields are made of plastic and are supported by bearings that cause them to rotate free of the main shaft.

(3) PTO accidents can be prevented by using the following practices:

(a) Disengage the PTO before stopping the engine and dismounting from the machine. Keep the PTO disengaged when servicing or repairing the machine.
(b) Operate the tractor only when the master shield is in place. It may be necessary to disconnect the shield when changing equipment, but it should be replaced immediately.
(c) Check the integral shield by rotating it by hand when the machine is stopped. Repair the shield if it or the bearings have been damaged.
(d) Tunnel shields will not operate properly if they are out-of-line. Align the shield and bolt securely in place.
(e) Refrain from stepping over a rotating shaft, even though it is protected by a cover.
(f) Properly phase or align the shaft universal joints if necessary. Some shafts cannot be reassembled improperly. However, some can be improperly assembled; therefore, they must be assembled in phase.
(g) One cause of shafts separating is that they fail to overlap enough and when one part of the unit (tractor and equipment) is higher than the other, the shaft comes apart. Therefore, use a shaft recommended for the proper connections.

c. Safety practices to observe when operating the tractor or machine brakes are:

(1) Check the brakes before putting the tractor in motion and after the tractor begins to move slowly. If the tractor is equipped with power brakes, press

each brake pedal to check the distance of travel. Lock the brakes together and operate the tractor slowly and use the brakes to determine if both are functioning the same. Use the operator's manual or service shop to make adjustments.

(2) Braking the tractor or machine:

(a) Use the individual wheel brakes to assist in steering the machine. If a short right turn is to be made, press the right wheel brake. This action slows the forward movement, resulting in a shorter turn.
(b) Lock the two brake pedals together when road driving the tractor. Pressure on one brake may upset the tractor at high speed.

(3) If fatigued or ill, begin braking the tractor or machine a few seconds sooner than when feeling fit. For example, when traveling 20 miles per hour, the machine will move about 7 feet for each 1/4 second.

(4) Check the operator's manual for proper braking methods when going down hill. The tractor may "freewheel", which means the engine will not help brake the downward speed.

d. Safety practices to observe when using lights and reflectors:

(1) When driving tractors and self-propelled machines on public roads at night, use the warning lights. These lights should be visible from both front and rear and mounted at the same level.

(2) When making turns, use the proper turning signal (visible from front and rear).

Most tractors and powered machines are equipped with red tail lights and reflector, work light, two amber warning lights on the rear, and two front lights.

(3) Use reflectors on equipment that is moved at night. If the equipment extends beyond the width of the tractor rear wheels, both flashing amber lights and reflectors may be used. This type of lighting system will require a special lighting system mounted on the equipment. Many types of reflectors and movable lamps are available for towing equipment.

(4) Use the machine on public roads at night only when both headlights are functioning. Set the lights so that they do not blind approaching drivers but are aimed properly in the path of the machine.

(5) Use mirrors that are designed for the machine. They may not be considered as standard equipment, but they are very valuable as a working and safety

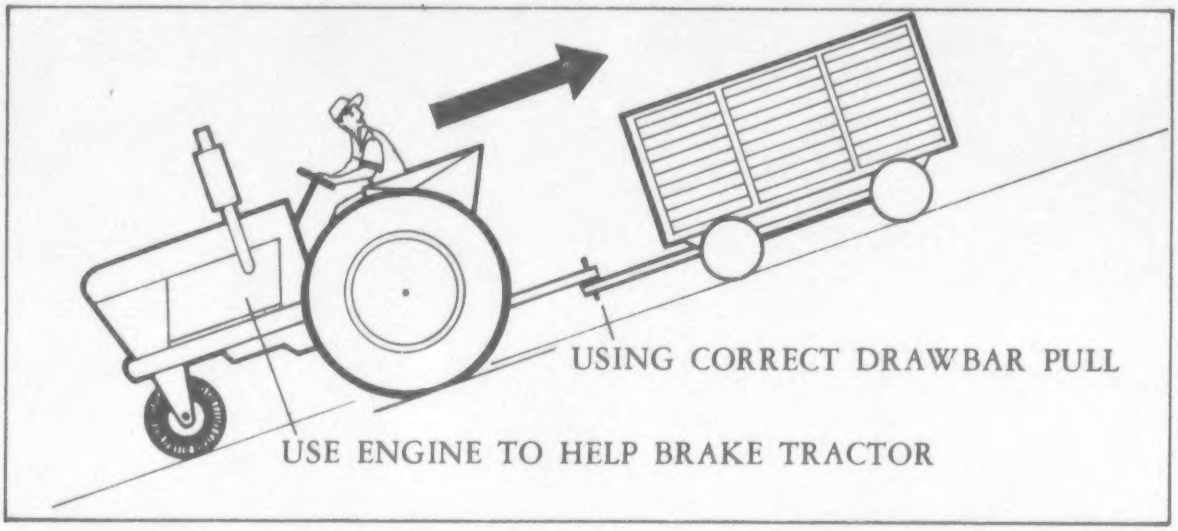
device. If the machine is not equipped with mounting brackets, construct them to eliminate vibration and being hit by an obstacle and yet give adequate rearward visibility.

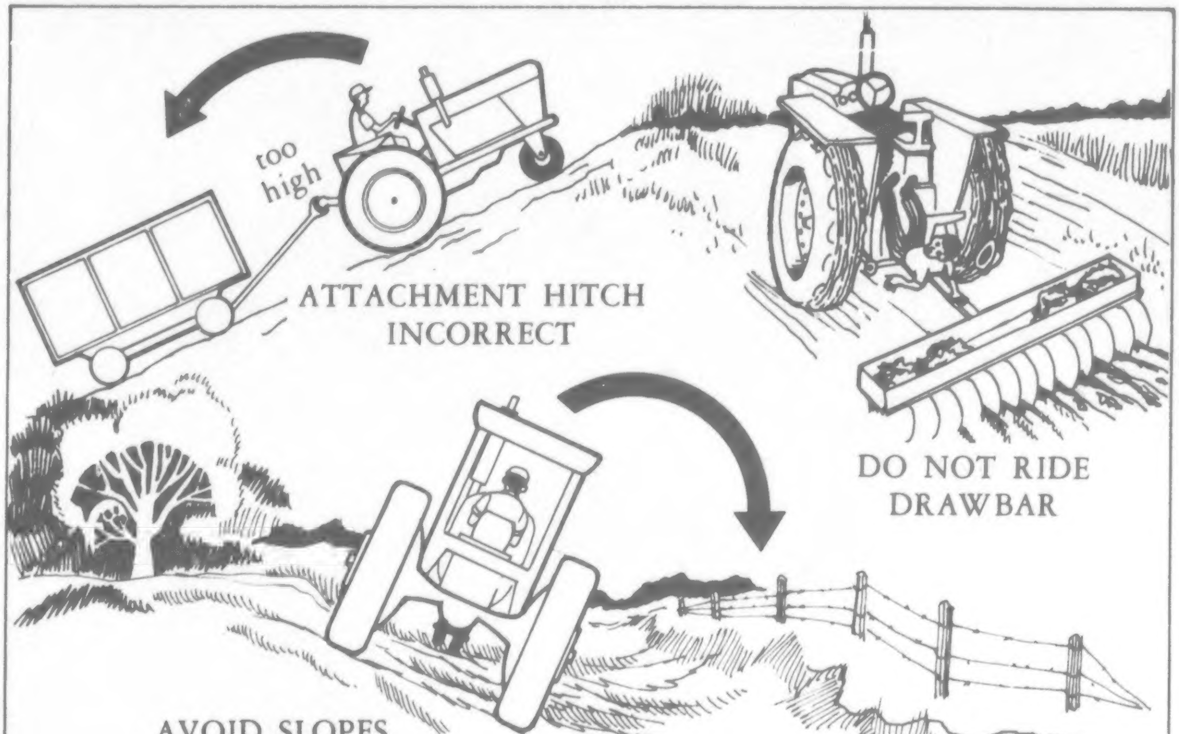
References:

1. Silletto, Thomas A. and Dale O. Hull, Safe Operation of Agricultural Equipment, Hobar Publications, St. Paul, Minnesota, 1975

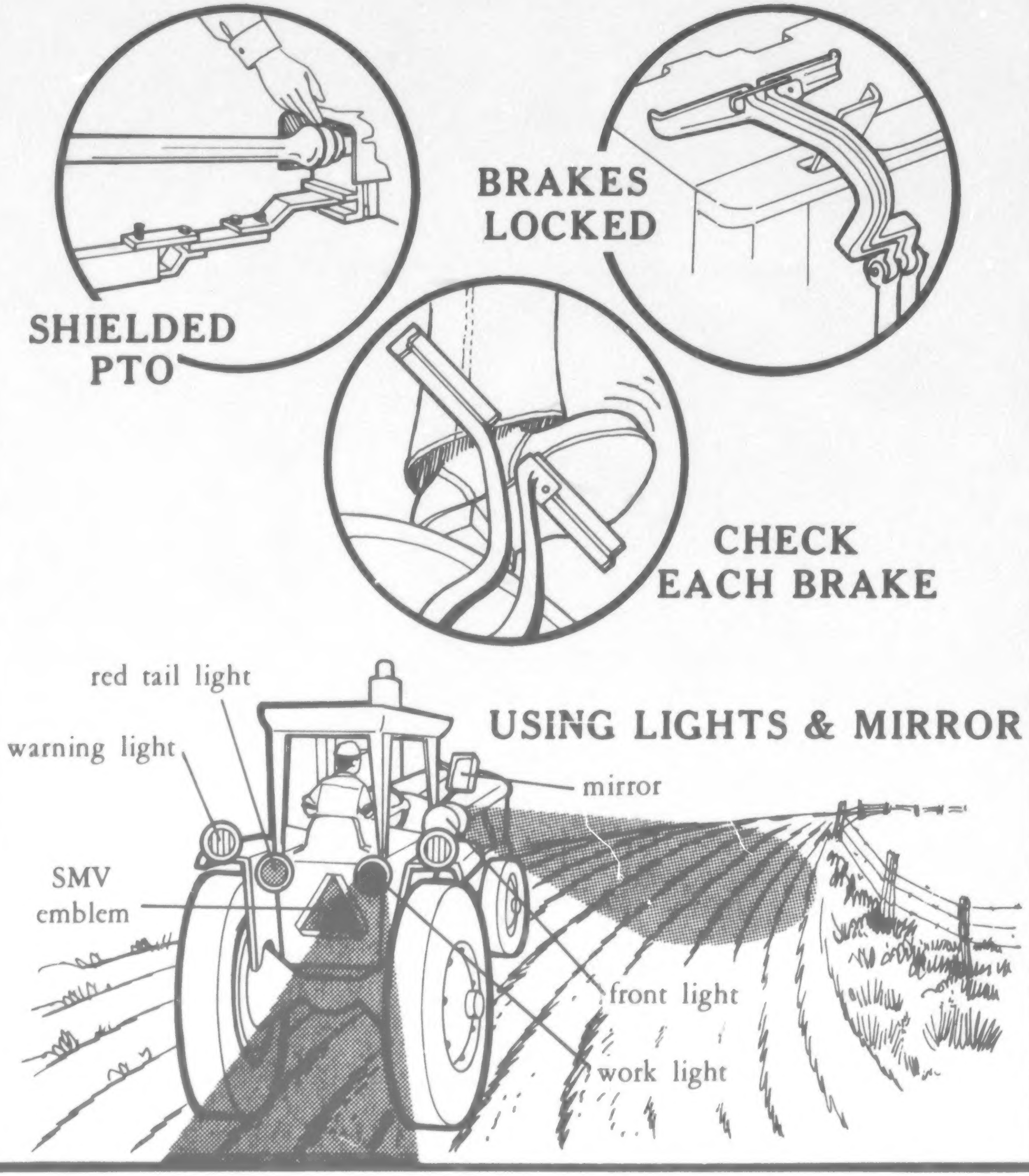
2. "Fundamentals of Machine Operation, Agricultural Machinery Safety", Deere and Company, Moline, Illinois, 1974

OPERATING TRACTOR


USING CORRECT DRAWBAR PULL
USE ENGINE TO HELP BRAKE TRACTOR


too high
ATTACHMENT HITCH INCORRECT
DO NOT RIDE DRAWBAR
AVOID SLOPES

OPERATING TRACTOR



SHIELDED PTO
BRAKES LOCKED
CHECK EACH BRAKE
USING LIGHTS & MIRROR
red tail light
warning light
mirror
SMV emblem
front light
work light

GENERAL AGRICULTURAL MECHANICS

Unit O: Planning An Agriculture Safety Program

Topic 2: Fire Prevention

Suggested Procedures and Activities: A fire extinguisher and different samples of fuel may be used during the classroom discussion.

1. Some Common Causes of Fires

    a. Tractor and equipment fires may be caused as follows:

        (1) Electrical shorts in the electrical circuits.

        (2) Fuel leaks due to loose or cracked lines.

        (3) Trash accumulation, dust, and chaff on the machine.

        (4) Broken or cracked sediment bulb. Most machines are equipped with metal or heat-treated glass bowls.

        (5) Malfunction of the carburetor on a gasoline unit.

        (6) Sparks from the exhaust.

        (7) Careless machine operators. Smoking and allowing the engine to operate (run) when refueling are considered two very dangerous acts.

    b. Fires in the shop and around the home are usually caused by the following reasons:

        (1) Old and improperly installed electrical circuits and units.

        (2) Failure to properly dispose of flammable objects and materials such as oily rags, wood scrap materials, and shavings.

        (3) Igniting paints, varnishes, lacquers, paint thinners, gasoline, and oil.

        (4) Pouring flammable liquids down drains. This practice can cause a very damaging explosion.

        (5) Spraying flammable insecticides and other flammable sprays in the presence of open flame.

(6) Storing flammable fuels and special cleaning liquids in regular containers instead of safety cans.

(7) Drycleaning clothing and other textiles with naphtha, benzine, or gasoline.

(8) Failure to use trash containers and ash trays properly around the home and shop.

(9) Lack of proper ventilation where flammable materials are stored.

2. Classifying the Different Types of Fires

   a. Class A Fires - Caused by wood, hay, paper, textiles, and rubbish burning. These fires can be quenched by water that is pressurized or nonpressurized.

   b. Class B Fires - Caused by oil, grease, gasoline, paint, and other flammable liquids burning. These fires are extinguished by a smothering effect. A pressurized dry chemical or CO_2 (carbon dioxide) extinguisher is recommended.

   c. Class C Fires - Caused by live electrical equipment such as heaters, motors, and switches. Pressurized dry chemical extinguishers are recommended for these types of fires.

3. Some Recommended Types of Fire Extinguishers

   a. Soda-acid - This extinguisher is one of the most common types and is found in many public buildings. Water in this extinguisher puts out the fires. When it is inverted, a bottle of acid mixes with the solution of soda-water, causing a reaction that provides pressure for the stream of water and acid. Disadvantages - If solution gets on a person, it could burn or blind. Also it will damage fabrics, etc. Once inverted, this extinguisher cannot be stopped until completely discharged. If hose became clogged (for example by a wasp) there could be an explosion. It should be pressure tested and recharged each year. Use for Class A fires only. Dangerous if used on electrical fires or oil fires. Qualified person must refill. This extinguisher is not recommended for vocational agriculture shops due to disadvantages listed above.

   b. Foam Extinguisher - This extinguisher is useful for Class A and B fires. In case of a "spill" fire, the foam must be used to build a wall around the burning fuel and then it can be placed over the flame to extinguish it. Disadvantages - Experienced personnel are needed to use such extinguishers and may not be available when needed. Results will probably be poor in the hands of an unskilled person. Refilling requires an experienced person.

c. Pressurized water - Advantages - Can be used on fire intermittently as desired. A glance at the gauge lets one know if it is ready to use. Anyone can refill easily by adding water, closing lid, and supplying air pressure. Use on Class A fires.

d. Pressurized Dry Chemical - Advantages - The active ingredient is ordinarily baking soda and cannot harm humans or fabrics. A child 10 years old can effectively use this extinguisher. It can be used intermittently as desired. The pressure gauge indicates when this extinguisher is ready for use. Disadvantages- A residue (baking soda) is left. On electrical fires, involving a motor or electronic equipment, this residue might have to be removed. This extinguisher must be recharged by a qualified person. Use on Class A, B, and C fires.

e. CO_2 Carbon Dioxide - Advantage - Especially good on electrical fires because of no residue. Disadvantages - It is only effective at close range. Released carbon dioxide gas (which puts out fires) could injure a person because of the resulting low temperature (far below 0^o). Sometimes a leaky valve will result in an extinguisher being empty when it is needed. An experienced serviceman must determine (by weighing) when the extinguisher needs a recharge. Refilling must be done by a qualified person. A funnel-shaped horn directs the fog discharge on the fire when held in a proper position. Use on Class A, B, and C fires.

Soda-acid and foam extinguishers must be completely cleaned and recharged once a year. The pressure should be tested every 5 years.

Cartridge operated extinguishers of all types are awkward to use and there is no way to determine whether or not they are in operating condition.

Important advantages of the newer recommended types (pressurized water and pressurized dry chemical) are the gauges that show at a glance if the extinguisher is ready for use. Also they require a minimum of maintenance and recharging is needed only after use. Recommended extinguishers for general use are both the pressurized water and pressurized dry chemical (with gauge). For tractor and equipment and some household uses, a 2 1/2-pound pressurized dry chemical extinguisher with gauge is adequate.

Fire extinguishers must be kept in strategic places. For example, in or near welding, painting woodworking, and machine repair areas. The extinguisher should be mounted on the wall at a proper height (about table top height) from the floor. Many prefer to mount extinguishers near entrances. There must be a vacated area around the extinguisher to make it accessible at all times.

4. Safety Precautions to Observe When Storing and Handling Fuels and Lubricants

Transparency No. 1

a. Storing and Handling Gasoline - Above ground gasoline tanks should be located as far as practical from buildings. The National Fire Protection Association recommends a minimum of 40 feet from the closest building. Tanks must be equipped with pressure-vacuum relief valves to prevent dangerous vapor pressures. A safety valve between the hose and tank is a must. It stops the flow of fuel in case of fire. The NFPA standard is for all above ground tanks to be equipped with safety valves that close automatically in case of fire. An underground tank with a pump provides the safest storage. Rust is a problem on underground tanks; therefore, care must be taken not to damage the tank coating when installing it. Usually an asphalt tar or mastic coating is used. Place an underground tank and pump on a sloping and well drained area. This type of tank can be located within about a foot from the nearest building.

Locate smaller containers (55 gallon drums) gasoline at least 40 feet from buildings. Store the drums outside closed buildings. Paint name of fuel on container. Never approach drum area with any flame that may ignite gasoline. Use pump to remove fuel from drum. Use an approved safety can to carry gasoline indoors. In this case, indoors means open ventilation. Most safety cans have a spring or valve to prevent the escape of vapors.

All gasoline stored above ground should be stored outside of buildings but placed under a shed. The tank should be painted white with gasoline printed on the front or side. White tanks stored under sheds lose much less gasoline than colored tanks exposed to the sun's rays. For example, a 300-gallon red tank will lose 9.6 gallons per month compared to a loss of 2.4 gallons per month for a white 300-gallon tank stored under a shed.

Transparency No. 2

b. Storing and Handling Diesel - Diesel overhead tanks should be placed at least 40 feet from the closest building. The National Fire Protection Association states that flammable vapors are released due to fuel spills while refilling machines and the storage tank. Diesel fuels may be stored the same as gasoline, in underground or overhead tanks, small drums, or safety cans. The containers should have the similar safety features as found on the gasoline containers, even though the fuel is not considered as flammable as gasoline. Most overhead diesel tanks are equipped with a vent pipe and filler cap. They do not have a special vapor pressure valve.

Kerosene can also be stored in the same manner as diesel fuel. It is not as flammable as gasoline, but it will give off flammable vapors when heated above 100 degrees F. Like gasoline and diesel fuel, it should never be stored in a closed building. An open shed should be used. Also, it should never by handled in open or glass containers.

Transparency No. 2

c. Storing and Handling LP-Gas

The LP-Gas tank should be placed a minimum of 50 feet from the nearest building. It should be 20 feet or more away from other fuel storage tanks. This distance gives adequate space for machines to travel between other structures and the tank.

Tanks are usually placed above ground in order that leaks can be readily detected by using a soap suds solution. However, LP-Gas tanks can be installed underground. Very rigid standards have been established by the National Board of Fire Underwriters regarding standards for storage tanks. A name plate is found on each storage tank, giving the tank pressure in pounds per square inch, the size in gallons of the tank, the name of the supplier, and whether the tank is to be used for underground or above ground purposes.

Some precautions to observe when refueling with LP-Gas are:

(1) LP-Gas is much heavier than air; therefore, refueling should not be over low places. Refueling should always be done outside of buildings. Use the vapor return line to equalize tank and machine pressure. The machine tank can be filled without vapor escaping to open air.

(2) Fill the machine (tractor or truck) tank only about 3/4 full. If the relief is forced to open, dangerous vapor escapes. Both automatic tank gauges and manually operated gauges are found on tractor tanks. The manual fixed tube-type gauges are operated by opening while the tank is being filled and closed after filling. Never permit any gauges to remain open after filling a tank.

(3) Refuel an LP-Gas tank when the engine is cool and stopped. Check the ignition switch to see that it is in the off position, and refrain from smoking until all vapors have been ventilated away.

5. Fire Prevention Practices

Most fires in and outside the farm shop are caused as the results of thoughtlessness of some individual. The best way to prevent losses caused by fire in the first place is to prevent the fire. Some fire prevention and control practices include:

a. Store flammables such as paint, lacquer, paint thinner, insecticides, and cleaning liquids in a separate small building. The location may be in the area of the fuel tank. If a small amount of these flammables are to be stored in the shop, place them in a metal cabinet with some ventilation. All flammables should be stored in approved containers. Inspect paint and chemical cabinets occasionally for fire hazards.

b. It is best to dispose of oily rags, wood scraps, and shavings. Put these flammable materials in a covered metal drum. This drum may be located outside the shop.

c. Locate the fire extinguishers, fire blanket, and water connections to use in case of fire. Be familiar with the use of all fire equipment and control measures. Inspect the extinguishers periodically.

d. Use only cleaning solvents that are safe. Gasoline is one of the most dangerous liquids that can be used as a solvent. Guard against these and other flammable liquids from being poured in the sink or lavatories.

e. Do not ignite the oxyacetylene unit or turn on the arc welder in the area of flammable materials.

f. Many serious accidents are the result of cutting or welding containers which held flammable materials. Fill such containers with water and vent the space above the water level before applying heat to the container.

References:

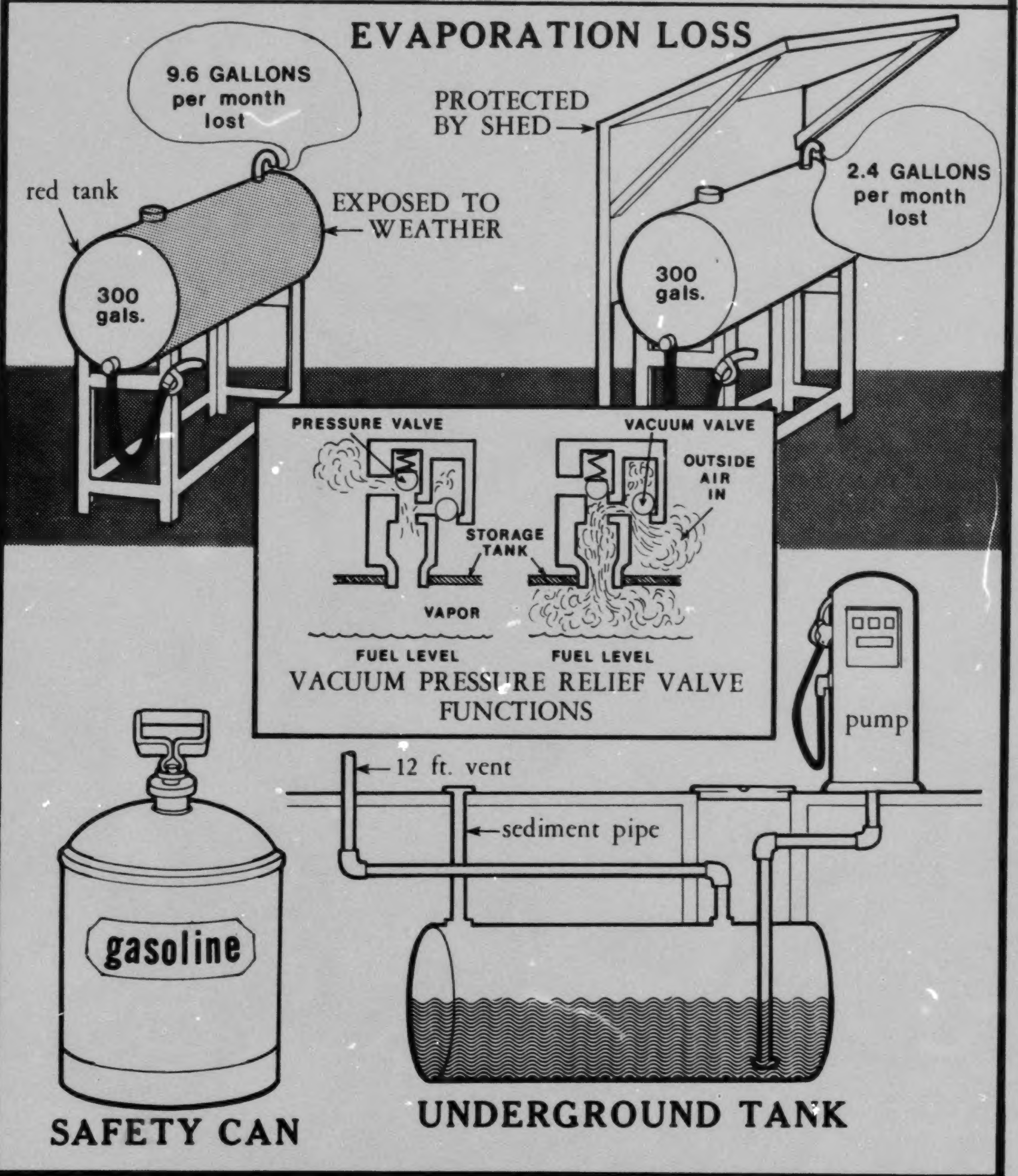
1. "Fundamentals of Machine Operation, Agricultural Machinery Safety", Deere and Company, Moline, Illinois, 1974

2. "Fundamentals of Service - Fuels, Lubricants, and Coolants", Deere and Company, Moline, Illinois, 1970

3. "Fuels and Lubricants, Selecting and Storing", American Association for Vocational Instructional Materials, Athens, Georgia, 1973

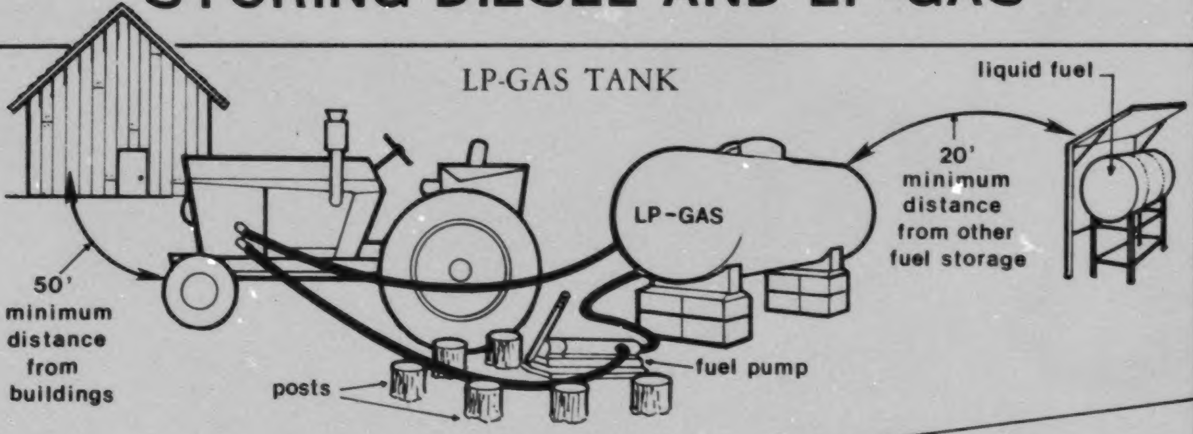
4. "Safety Practices in Agricultural Education", State Department of Education, Tallahassee, Florida, 1966

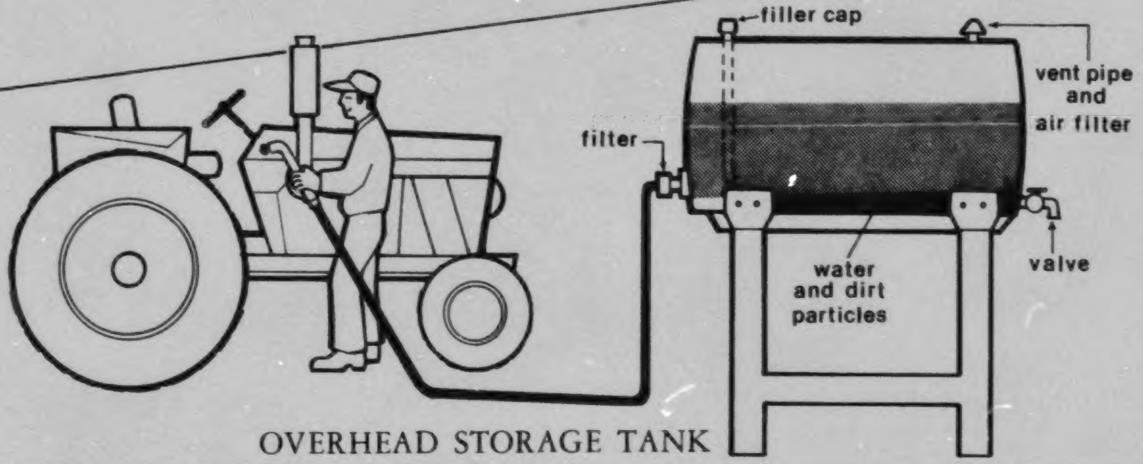
STORING GASOLINE


EVAPORATION LOSS
9.6 GALLONS per month lost
red tank
EXPOSED TO WEATHER
300 gals.
PROTECTED BY SHED
2.4 GALLONS per month lost
300 gals.
PRESSURE VALVE
VACUUM VALVE
OUTSIDE AIR IN
STORAGE TANK
VAPOR
FUEL LEVEL
FUEL LEVEL
VACUUM PRESSURE RELIEF VALVE FUNCTIONS
pump
12 ft. vent
sediment pipe
gasoline
SAFETY CAN
UNDERGROUND TANK

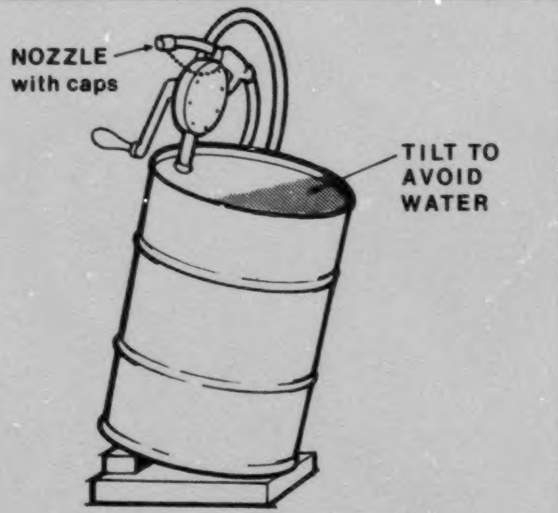
STORING DIESEL AND LP-GAS

LP-GAS TANK

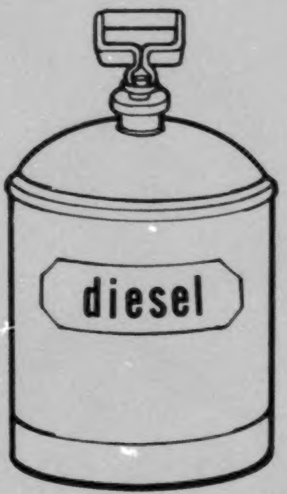

liquid fuel
LP-GAS
20' minimum distance from other fuel storage
50' minimum distance from buildings
fuel pump
posts


filler cap
vent pipe and air filter
filter
water and dirt particles
valve

OVERHEAD STORAGE TANK


NOZZLE with caps
TILT TO AVOID WATER

55-GALLON DRUM



5-GALLON SAFETY CAN

GENERAL AGRICULTURAL MECHANICS

Unit O: Planning An Agriculture Safety Program

Topic 3: Safety Building Practices

Suggested Procedures and Activities: If the floor plan of the shop is available, it may be used as an aid during the class discussion by pointing out both the weak and strong points in ventilation, lighting, and color schemes.

1. Laying Out and Arranging a Shop to Prevent Hazards

   a. Location - Locate the shop building on a well drained site with adequate space around the building for a concrete apron and movement of equipment. The shop should be accessible to the center of operation (near the home) and have at least one large service door.

   b. Size - The size of the shop will be determined by the size and type of equipment to be maintained, type of tools used, storage area needed for spare parts, and supply area needed. Draw a floor plan showing size of shop.

   c. Arrangement - The shop area should be large enough that work benches, equipment, tool racks and cabinets, and bins can be arranged around the walls leaving space to work on machines. Show on drawing the arrangement leaving an uncluttered work area for machines to be serviced.

   d. Equipment Arrangement - Locate each shop area on a floor plan sketch showing metal work, cabinets, and metal work supplies in one area; woodwork, cabinets, and woodwork supplies in another area; and storage bins and supplies in a third area.

   e. Lighting - Shops should have adequate window space to furnish sufficient light during daylight hours. Skylight roofing can add light even with window lighting. All shops need overhead lights which must be used at night and some days when there is a lack of sunlight. Portable lights are also a necessity in a shop. They bring adequate light directly to the work and eliminate shadows when working in certain positions. Light painted walls will also help eliminate shadows by putting more light on the subject.

   f. Wiring - All shops should have both 120- and 240-volt circuits. Motors that exceed 1/2 horsepower and welders require 240 volts. Install enough conveniently located outlets around the walls to reduce the use of an extension cord.

2. Shop Ventilation

Most shops are constructed with enough doors and windows to provide adequate ventilation. However, weather conditions may control the use of these building openings during certain seasons of the year. Generally, the door and window area should equal about 25 percent of the floor space.

If doors, windows, and louvers cannot provide adequate ventilation, then artificial methods must be used to clean the area of fumes, smoke, dust, and certain chemicals that may contaminate the air.

a. The so-called artificial means of ventilating a shop are:

(1) Ventilating fan placed in wall of building forcing inside air outside of the building. Foul air is removed from the entire shop by this system.

(2) Hoods equipped with exhaust fans that force air through ducts to the outside. This is the most efficient system for removing foul air from a small work area. Both the ventilation fan and hood exhaust system must be able to pull in fresh air from a louver, door, or window in order to function properly.

(3) Tube exhaust venting systems which are used to remove exhaust fumes from an operating engine. The tube is placed over the exhaust pipe of a machine and it extends through the wall where the fumes pass to the outside. There is no fan in the tube, so the carbon monoxide gas is forced outside through pressure build up in the exhaust pipe.

Fans that circulate air within a shop area cause a small amount of air to be moved to the outside of the building. The main purpose of this type of fan is to cool. Ventilating fans also are used as cooling fans by pulling in fresh cool air and forcing out stale warm air. Another type of circulation that moves the air around in a given area is the heating unit fan. This type of unit affects ventilation only if doors or windows are open.

b. Areas that are considered important to ventilate are:

(1) Welding - Smoke and vapors are removed.

(2) Painting - Fumes are removed.

(3) Chemical Storage (Liquid and Dust) - Poisonous dusts and/or fumes are removed.

(4) Machine Maintenance and Repair - Carbon monoxide gas is removed.

3. Using Color Schemes

In a small repair and maintenance shop color coding equipment and work areas is used mainly as a reminder of safety precautions to be observed by one or two people. Regardless of the number of people involved, it is a sound practice to use all safety measures possible to prevent an accident.

a. There are seven colors that are commonly used in a safety color dynamic program. They are:

   (1) Red - This color indicates the location of equipment to extinguish fires. The fire equipment and the area where it is located should be painted red or painted with red bands.

   (2) Orange - Orange means danger, especially moving parts on machines or equipment; therefore, power tool guards, pulleys, cutting edges, and the inside doors of fuse and switch boxes are painted orange to designate the location of dangerous parts.

   (3) Yellow - The color yellow designates caution as applied to operating wheels, levers, and other controls. It is used to mark aisles, handrails, equipment location, and hazardous places that could result in a fall. It is also used to mark gear handles and levers on machines and equipment.

   (4) Yellow and Black - Yellow and black strips can be used to mark raised entrance areas such as door sills, center posts in shop, barn, and sheds and corners of buildings next to traffic entrances.

   (5) Green - The color light green is found on the body and base of power tools such as grinders, drill presses, and work benches. This color refers to the safer part of the machine or piece of equipment.

   (6) Ivory - This color is used for tops and edges of benches, inside of cabinets, and nonmovable edges of power equipment. Buff or ivory adds to visibility of machines and equipment. It also adds to the effectiveness of other colors.

   (7) Green - Safety green is a color to mark first-aid kits and cabinets for quick location. A green cross painted above the kit or on the cabinet is still more effective than the kit being painted. This green color should not be confused with the high-visibility light green color.

b. The uses of paint and vinyl is as follows:

   (1) Paint - Quick-drying synthetic resin base exterior enamel paints are used to paint the different colors on the machines and equipment. If yellow and black stripes are painted, use either yellow or black to paint a solid color strip. After it dries, use gummed masking tape in strips at an angle on the solid painted strip and apply the other color

paint (yellow or black).

(2) Vinyl - If the floor area is identified, vinyl yellow strip, yellow and black strips, or yellow discs may be used.

References:

1. "Fundamentals of Machine Operation, Agricultural Machinery Safety", Deere and Company, Moline, Illinois, 1974

2. "Shop Planning, Basic Design of Shops and Service Centers", American Association for Vocational Instructional Materials, Athens, Georgia, 1975

3. "Safety Practices in Agriculture Education", The State Department of Education, Tallahassee, Florida, 1966

GENERAL AGRICULTURAL MECHANICS

Unit O: Planning An Agriculture Safety Program

Topic 4: Safety Reminders and Precautions to Observe in the Shop

Suggested Procedures and Activities: The use of students as demonstrators may be of value during the classroom discussion. For example, have students dress properly for the shop, woodworking area, welding area, and paint area. A student may demonstrate how to lift heavy objects by hand. Another student or pair of students may demonstrate the use of the first-aid kit.

Transparencies Nos. 1 and 2

1. Shop Safety Reminders

   a. Good Housekeeping - A clean shop is usually a safe shop. Some examples of good housekeeping are:

      Shop work benches are clean.

      Shop floor is clean.

      Fire hazards (wastes such as sawdust, old rags, and shavings) are removed from the shop.

      Materials and supplies are restored to their proper place.

      Tools are kept in their proper place.

   Some examples of poor housekeeping include:

      Cluttered work areas.

      Dirty, wet, greasy floors.

      Tools lying around the shop.

      Materials protruding into open walkways.

      Loose objects and materials of various kinds on the floor.

b. Use of Protective Devices - Eye protection is inexpensive, and good eyesight is priceless. Some injuries may be as slight as a scratch; yet, others may be permanent. Safety devices and their uses include:

Goggles - When welding, grinding, drilling, or chipping certain objects, using a wire brush, and handling certain chemicals, goggles should be worn.

Protective Clothing - Clothing should be free of flammable materials, pockets, and ragged ends when welding. Also, the sleeves and collar should be buttoned. High-topped shoes may eliminate burns from slag or sparks created by the welder. Loose clothing, shirt tails out of trousers, long sleeves, and ties are shop hazards when using power tools.

Gloves - Hand pads or gloves are necessary when handling sharp, heavy, hot, or rough materials around a shop. When welding, fire resistant gauntlet gloves must be used to protect the hands and wrists from burns.

Welding Helmet - A welding helmet is absolutely necessary for protecting the eyes and face from arc rays and splattering hot metal particles.

Respirator - Respirators are used to protect the student from inhaling paints and their ingredients when spray-painting.

c. Behavior in the Shop - Shop workmanlike manners should be practiced at all times. Some bad behavior practices are:

Scuffing
Wrestling
Giving the 'hot foot"
Being idle
Running
Talking to classmates
Pushing
Tripping
Loud talking
Hurrying on project
Playing with tools
Disobeying other shop rules

One reckless student can make the entire shop unsafe. The reckless shop student should be considered in the same light as a reckless driver; that is, he is failing to consider his safety and the safety of his fellow students. Good citizenship is regarded very highly in the shop.

d. Handling and Placing Materials Used in the Shop - There are several methods the student can use to properly handle and place materials in the shop.

Heavy objects in farm machinery work should be handled by blocks or block and tackle, suspended from an A-frame or other well-supported structure.

To lift a heavy object by hand, a student should use the following procedure:

Lift with the legs to avoid back and abdominal injuries

The feet should be kept apart, knees bent, and the back straight as the load is lifted with the legs.

The load is lowered to the floor using the same method as when lifting except that the knees are bent downward.

While carrying a load, the hands and body should not be shifted to another position.

If the load is heavy, ask for help.

Rough materials and metal should be handled with gloves.

Materials should be stacked in a place that is a safe distance from aisles, working areas, and entrances. The materials should be stacked in such a way that they will not slip, crush, or fall. Materials should be handled in such a way that the pieces or parts will not strike anyone in the working area. More than 25 percent of all disabilities are caused by the improper handling of materials.

e. A ladder is a very important piece of shop equipment. Ladder safety depends upon how and where the ladder is used. A makeshift box or crate should not be used in place of a ladder to inspect machinery, replace ceiling light bulbs, paint walls, hang fixtures, or work on anything above one's reach. The following ladder safety measures should be observed:

Check the ladder for missing cleats.

Check the ladder rungs for cracks and weaknesses.

Check the ladder for broken spreaders.

The base of a straight ladder should be about one-fourth its length from the wall.

A folding step ladder should be opened and locked open.

Use both hands when climbing a ladder, and do not reach for an object too far away when on a ladder.

Transparency No. 3

2. Precautions to Observe

a. Hand Tools - Over one-fourth of all shop injuries are caused by the use of hand tools. The injuries stem from three principal causes:

Improper use of the tool
Using the wrong tool for the job
Using defective tools

Transparencies Nos. 3 and 4

b. Precautions to Observe When Using Hand Tools - These precautions are:

A dull tool may slide or stick to the material causing an injury; therefore, cutting tools should be kept sharp.

Tools with mushroom heads (cold chisel with spreading head) are dangerous. A chip may break off and strike any part of the body. Splintered, broken, or loose tool handles can also cause flying objects.

A screwdriver is not to be used as a cold chisel, pry bar, paint paddle, putty knife, or punch. Each tool is made for a specific job or jobs, and if the job is to be done safely and quickly, the proper tool should be used. Use the proper sized tool for the job.

No tool should be allowed to lie around. Tools should remain in their proper places when not in use, and the sharp edges of cutting tools should be protected. Sharp edged tools are dangerous if placed in improper locations.

Tools are never to be carried in the pocket. Sharp or pointed tools are very dangerous in any pocket on the body. A tool box or tool kit and belt tool holders are safe carriers.

Badly worn tools are dangerous, especially pliers and wrenches with jaws. Using a hammer to strike a handle or extended handle to gain more pressure is not a safe practice. Improper sized wrenches may slip on bolt nuts and cause injury to the knuckles. Adjust the jaws of adjustable wrenches so they will not slip.

Greasy or dirty tools are difficult to handle properly. Clean tools make the work more efficient. Tools should be cleaned before they are put on the tool rack.

All work should be held steadily and the cuts made away from the body except when using a draw knife. If vises are used to hold the work stocks, they must be mounted securely.

Tools that have tang handles should be provided with a slip over the handle to protect the hand. For example, a file is dangerous if used without a handle to cover the tang.

c. Precautions to Observe When Using Jacks and Hoists

(1) Jacks, like many other tools, are considered safe if used properly and unsafe if not used according to recommendations. Observe the following when using jacks:

Check the jack's rated capacity and use accordingly. Do not use to lift overloads. An overloaded jack that fails is very dangerous.

Use the operator's manual to determine points of lubrication, and lubricate as recommended. Also check the hydraulic fluid in the hydraulic type jack, and fill with recommended jack oil.

Position the jack so that the lift shaft will be vertical to the ground or floor. The place the jack lift touches the machine should be strong enough to carry the weight, flat and level.

When working from the ground, use a heavy block under the jack. Do not use extenders between the jack and machine. One large solid block is safer than several small blocks.

Before lifting a machine with a jack, stabilize it. Set the brakes and place the transmission in gear or in park. One wheel touching the surface should be blocked. Equipment can be stabilized by hooking it to the tractor.

After lifting the machine off the surface and it begins to shift, lower the machine, reset the jack, and reblock the machine. Check to determine whether or not the jack saddle is sliding on the frame.

Jack handles can be dangerous if not held firmly. Stand to one side of the handle while holding and releasing it. Remove the handle from the jack as soon as the machine is raised to the proper height.

After the machine or equipment is raised to the proper height, support it with blocks or stands. This should be done immediately after reaching the proper height. Most support stands are converted to a rigid stand by using a lock pin.

(2) Hoists, like jacks, can cause serious accidents. The improper use of both can result in crushing injuries to the individual. Most hoist accidents are caused from slipping chains and overloading. To use hoist equipment safely:

Check the chains for extreme wear, bent links, and cracks. Damaged links can be replaced with new links, but if the entire chain is worn it should be replaced. A severely worn or damaged chain may be repaired by the manufacturer.

Check the hoist hooks for damage. A cracked, bent, or sprung hook should be replaced. If in doubt about the condition of a hook, compare it with a new one before replacing it.

Use the hoist according to capacity recommendations. Do not exceed the load the hoist should lift. Consider the A-frame load when using a hoist. It must be strong enough to withstand the lifting and hold the desired load.

Attach the hoist at the proper place on the A-frame. Some frames are made only for a center hook up and will not withstand a sideways pull. Have the machine or implement centered so that it will balance under the frame. It may be possible to tip the A-frame if the machine or equipment is not directly under the frame beam.

Stand at a safe distance from the machine or implement being lifted. Keep hands away from areas that may cause injury. Pay careful attention to the object being lifted as it leaves the ground or floor. Place the machine or implement on blocks or stands immediately after lifting.

Transparency No. 5

d. Precautions to observe when using portable electric power hand tools include:

Check the tool before using. The three-prong plug (one of the prongs is for grounding the tool) should be free of damage.

Keep the cord out of the aisles or other traveled areas and protect it from hot or rough surfaces, oils, and chemicals.

Electric hand tools should not be used around flammable vapors or gases; a spark can cause an explosion.

The hands should be dry when using a power tool. Dry hands may reduce the shock effect if there is an improper ground or short in the tool.

Always remove the cord and plug from the outlet by grasping the plug instead of grasping the cord.

The tool should remain on a shelf or rack when not in use. The cord should be rolled loosely when storing the tool.

NOTE: Hand power tools should be used by experienced students, those that have been instructed in safe methods of using them.

e. Precautions to observe while working with electricity or electrical equipment include:

Locate and check the use of the master and other switches in the shop.

All electrical tools should be checked for damaged parts, plugs, cords, and grounding prongs or wires before using on any job. Sparking or smoking of a motor is a signal to disconnect the equipment and report the condition.

Extension cords should be of adequate size to handle the electrical load. Exposed wires, faulty plugs, and worn insulation are danger signs on extension cords. They should not be placed in aisles or pulled over sharp edges. Cords should be protected from damage by the power tool. They should be disconnected by pulling the plug from the outlet.

Electric portable tools should not be used on damp floors or with wet hands. Rubber-soled shoes are the safest shoes to wear when handling electrical equipment.

When fuses blow, there is an indication of an overload or a short. A supply of proper sized fuses should be kept on hand.

When cleaning electrical tools, the proper solvent should be used. Gasoline is very flammable and should not be used.

NOTE: An electrician considers all wires as live wires until proven to be different. Bare fingers are not used to check whether a circuit is energized or not. The control switch is locked open if work is required on the circuit.

When working with electricity, the following steps should be observed:

Splices should be soldered and taped.

Screws should be tightened firmly, connecting the wire to the fixture.

Proper sized wire should be used. Follow the rules of the National Electrical Code to determine the wire size.

f. Precautions to observe concerning special shop hazards include:

Chemicals (acids and caustics) should be used under the direct supervision of someone who is acquainted with their proper use and dangers.

Compressed air is very dangerous, and it should be used with caution when painting and cleaning clothing and equipment. It should never be used under the following conditions:

> Pointing nozzle at the body as a prank; it can damage the eyes and ears very easily.
>
> Kinking the line to cut off the air or reduce the air flow through the hose.
>
> Cleaning the equipment where metal waste is located, without protecting the eyes.
>
> When the pressure is too high for the job being done.
>
> To remove liquid from surfaces.

3. Safety Goes Beyond the Use of Tools

a. The student is usually not like the safe electrician who automatically keeps all tools in good condition, knows exactly how to install wires and fixtures without endangering himself and others, knows about the dangers of electricity, and has a complete knowledge of the field work. The electrician's entire education on the subject has caused him to develop a safe attitude. So, the electrician's education on the subject includes habits, skills, knowledge, and attitudes favorable to safe work.

b. The student must become safety conscious if he is to develop safety habits. If he knows that the way he is doing something is dangerous, he should stop and change to a safer way. An accident might be prevented.

c. If a student follows shop rules and regulations, there will be little or no danger of having a shop accident. One of the first requirements in an agricultural mechanics shop is to observe all shop safety rules. If the safety rules are not observed, accidents will happen. For example, a factory supervisor became lax and permitted his personnel to work without goggles; within one month eye injuries went up five percent. Rules are enforced to protect the student.

d. Each student is responsible for reporting certain things dealing with the shop program, especially when they are related to shop safety. Some things that should be reported are:

Tools and equipment that are damaged, broken, or not in condition to be used to produce good quality workmanship.

All fire hazards and other hazards endangering the student, such as oil on the floor, lack of ground wire on electric power equipment, and accidents and injuries occurring in the shop.

Defective or missing protective equipment and devices (goggles, shields, and guards) for use when using the grinder, welder, and other power-operated equipment.

Lack of enough work to stay busy during the shop period.

4. First Aid in Agricultural Mechanics

   a. Minor injuries, such as cuts, bruises, scratches, burns, or punctures, should be treated immediately. The shop first-aid kit may be a handy device to treat minor injuries. In many cases, the school nurse is called to assist with injury treatments. The student should report minor injuries to the instructor.

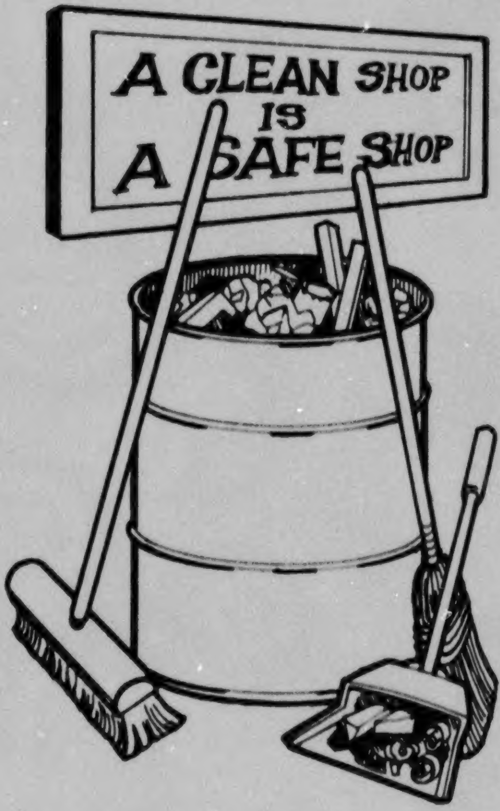
   b. Major injuries, such as severe shock, scalds, burns, cuts, and broken bones, should be handled immediately by qualified school personnel and a physician. First-aid is administered before the student is sent to the hospital only if advised by the instructor; otherwise, the placing of splints, applying of tourniquets, or administering artificial respiration should not be a general practice by the student.

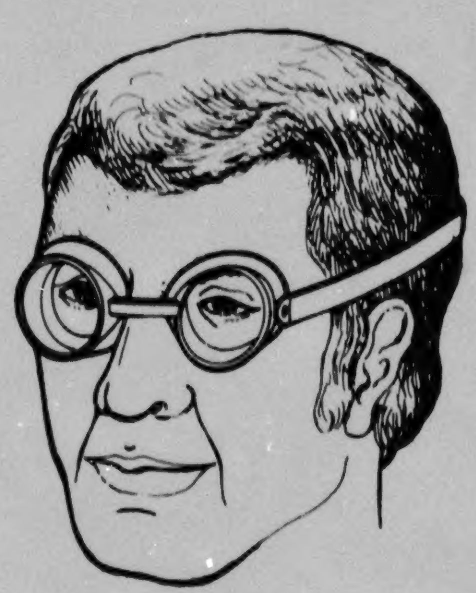
References:

1. Phipps, Lloyd J., Mechanics in Agriculture, The Interstate Printers and Publishers, Inc., Danville, Illinois, 1967

2. "Safety in the Agricultural Mechanics Shop", University of Illinois, Urbana, Illinois, 1969

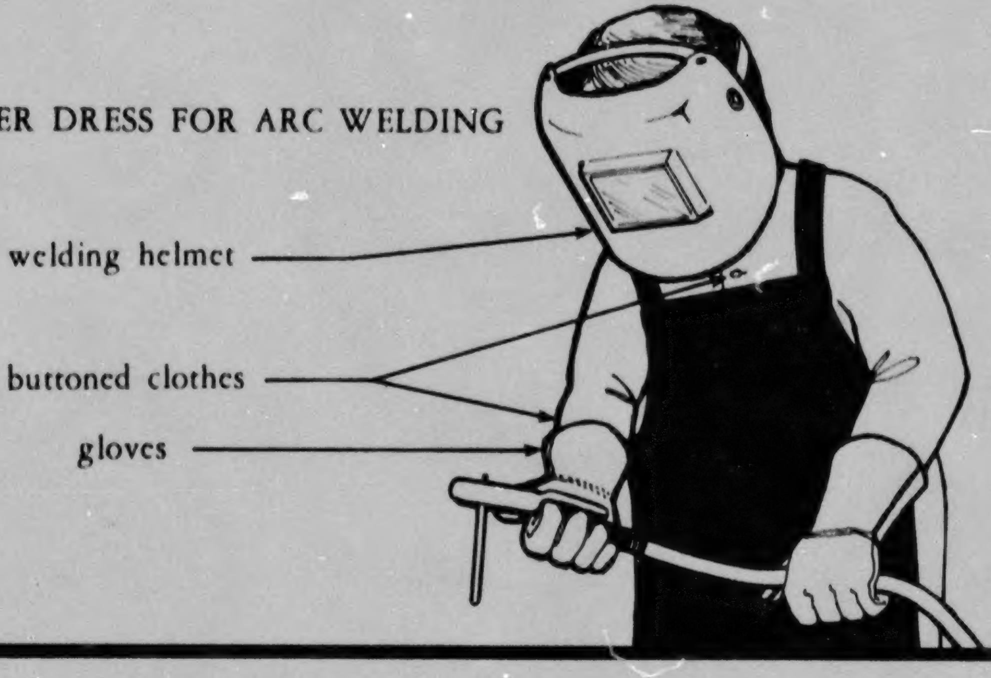
SHOP SAFETY


A CLEAN SHOP
IS
A SAFE SHOP



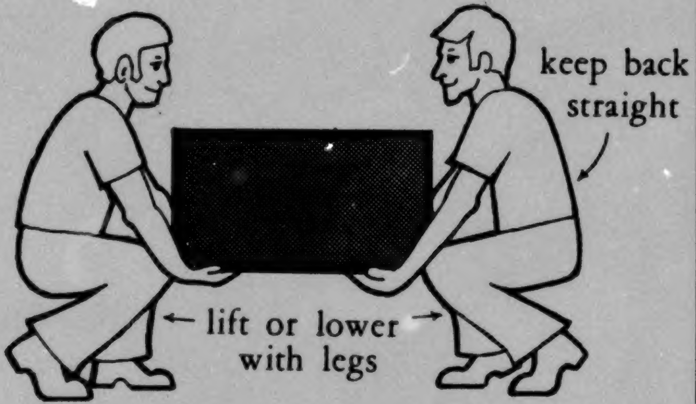
USE PROTECTIVE GOGGLES

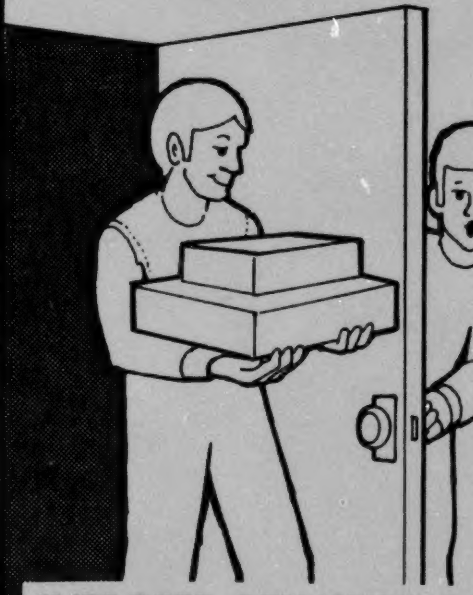
PROPER DRESS FOR ARC WELDING


welding helmet
buttoned clothes
gloves

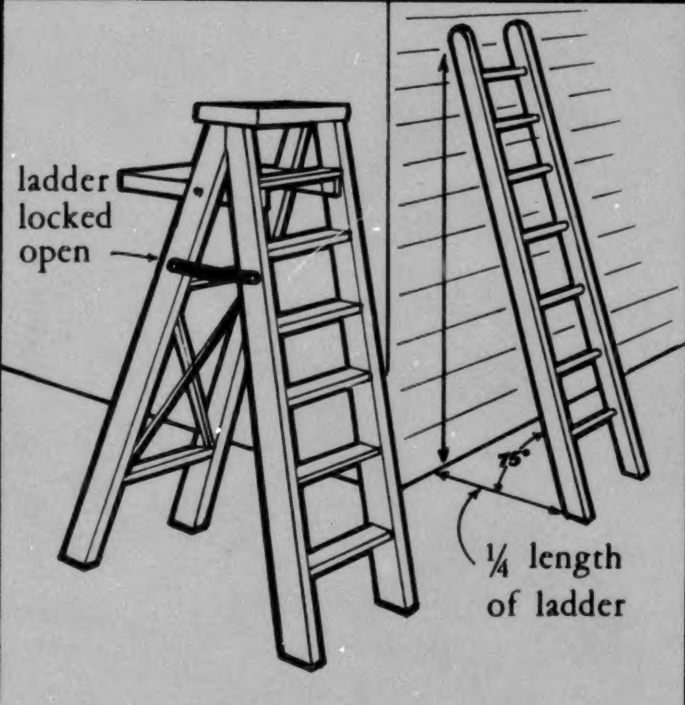
SHOP SAFETY

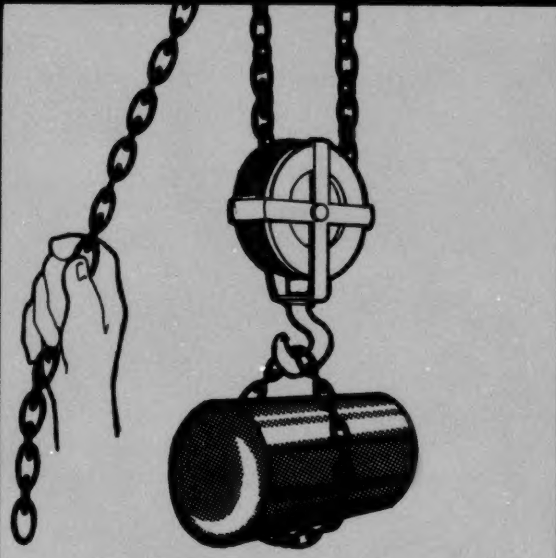
GET HELP TO HANDLE HEAVY OBJECTS


keep back straight
lift or lower with legs



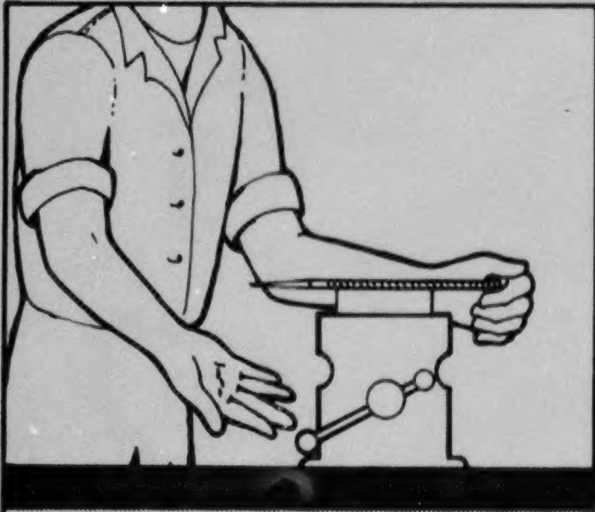
IMPROPER BEHAVIOR CAN BE DANGEROUS


ladder locked open
75°
¼ length of ladder

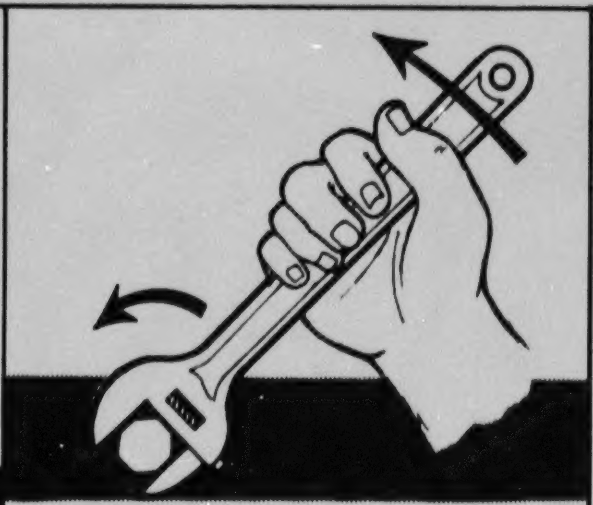


SAFE METHOD OF MOVING HEAVY OBJECTS

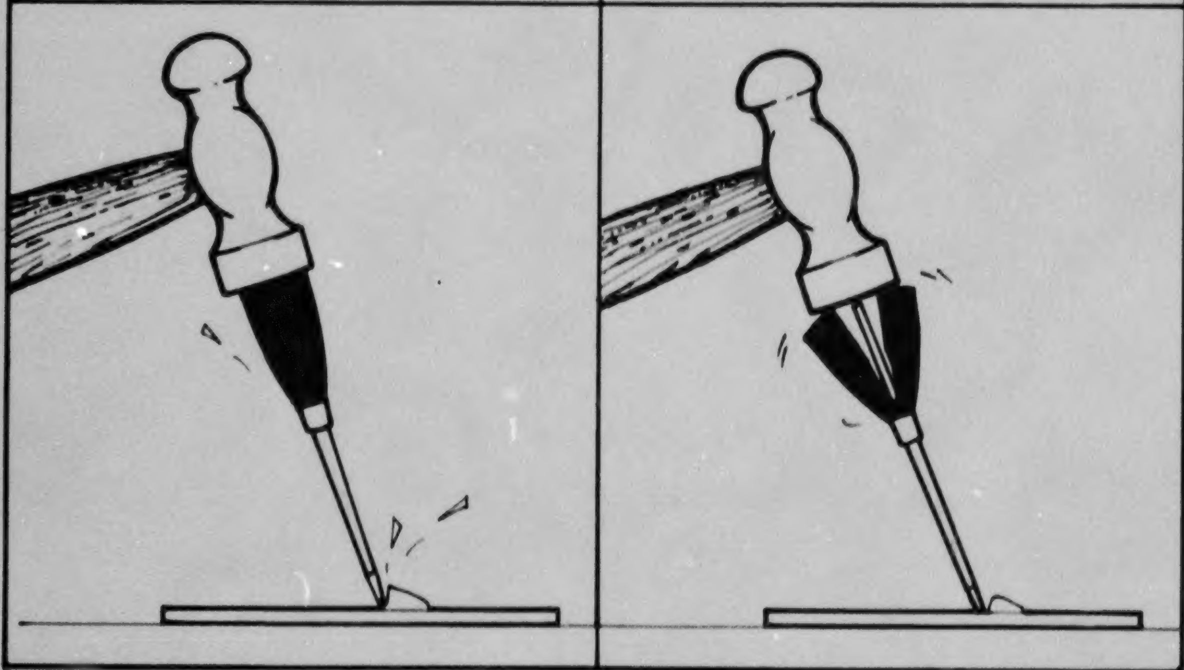
SHOP SAFETY-HAND TOOLS



FILES WITHOUT HANDLES
CAUSE INJURY

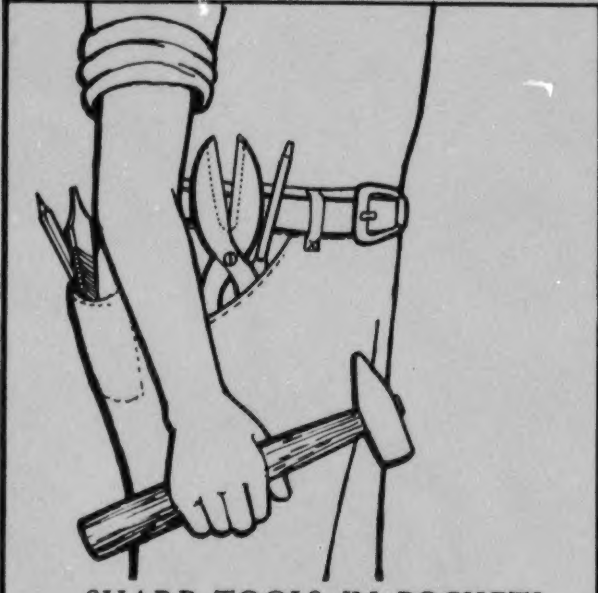


IMPROPER USE OF WRENCH
CAN CAUSE INJURY

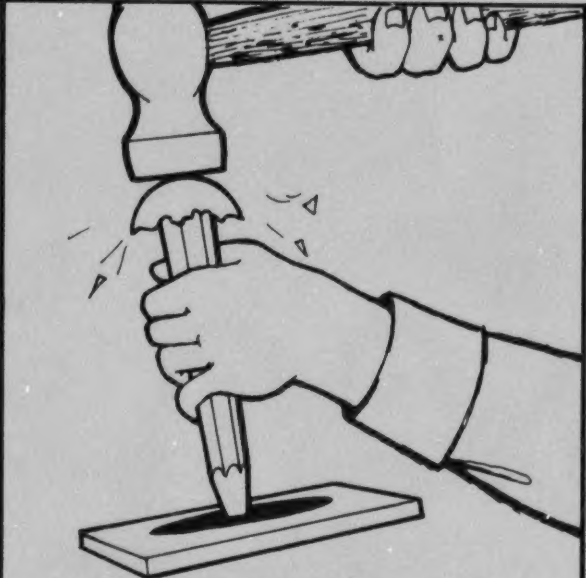


TOOL USE

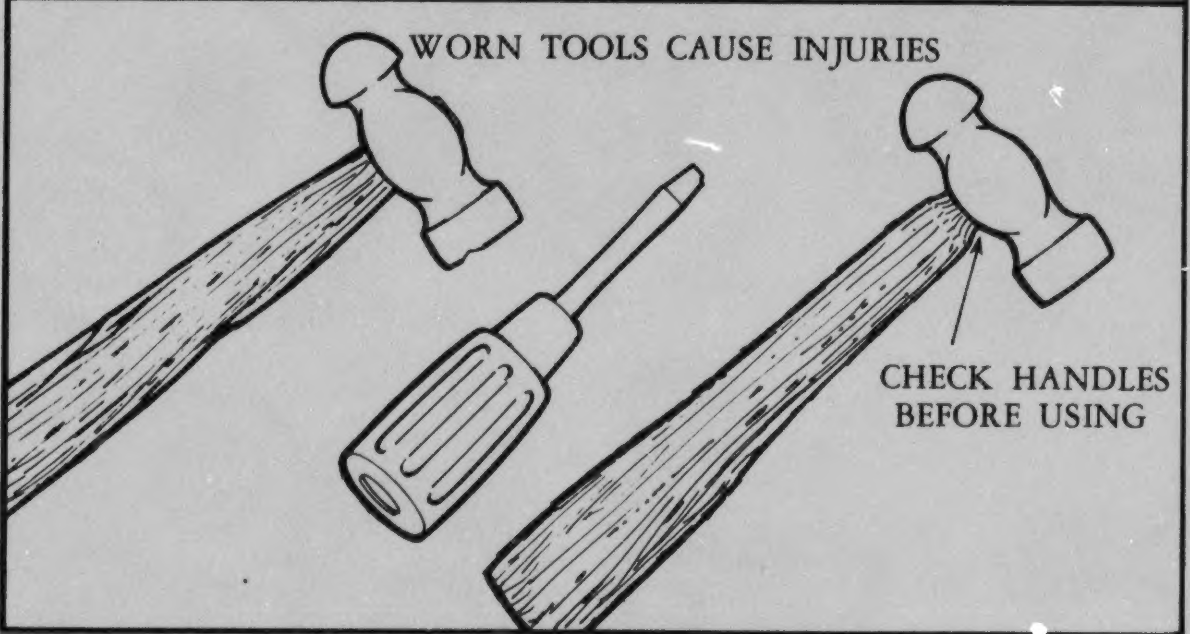
SHOP SAFETY-HAND TOOLS



SHARP TOOLS IN POCKETS ARE DANGEROUS

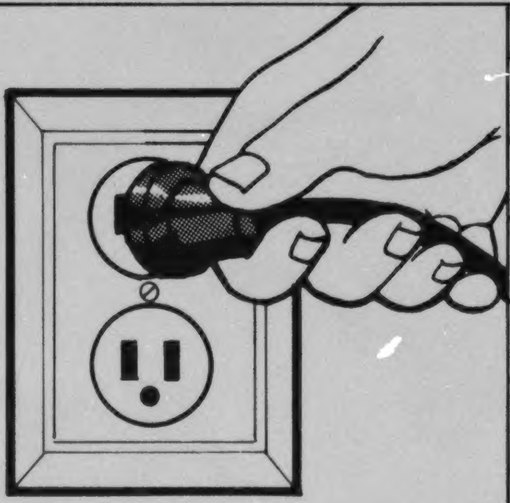


MUSHROOM HEAD SLIVER CAN CAUSE INJURY


WORN TOOLS CAUSE INJURIES
CHECK HANDLES BEFORE USING

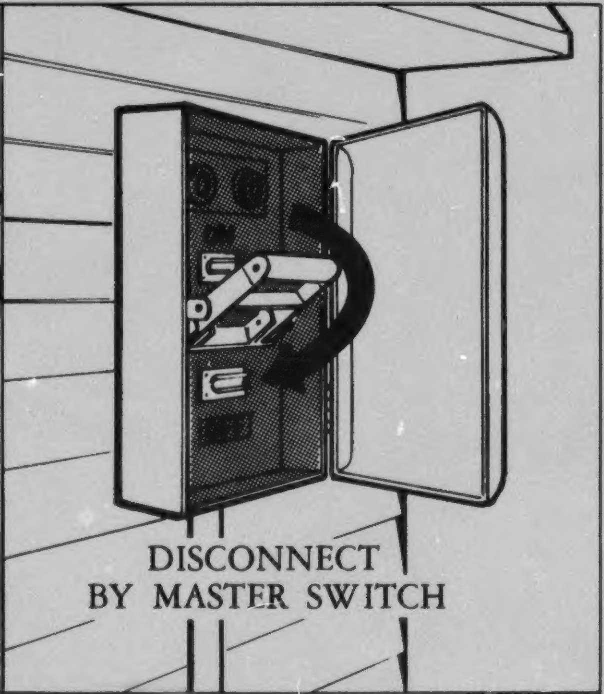
TOOL CARE

SHOP SAFETY

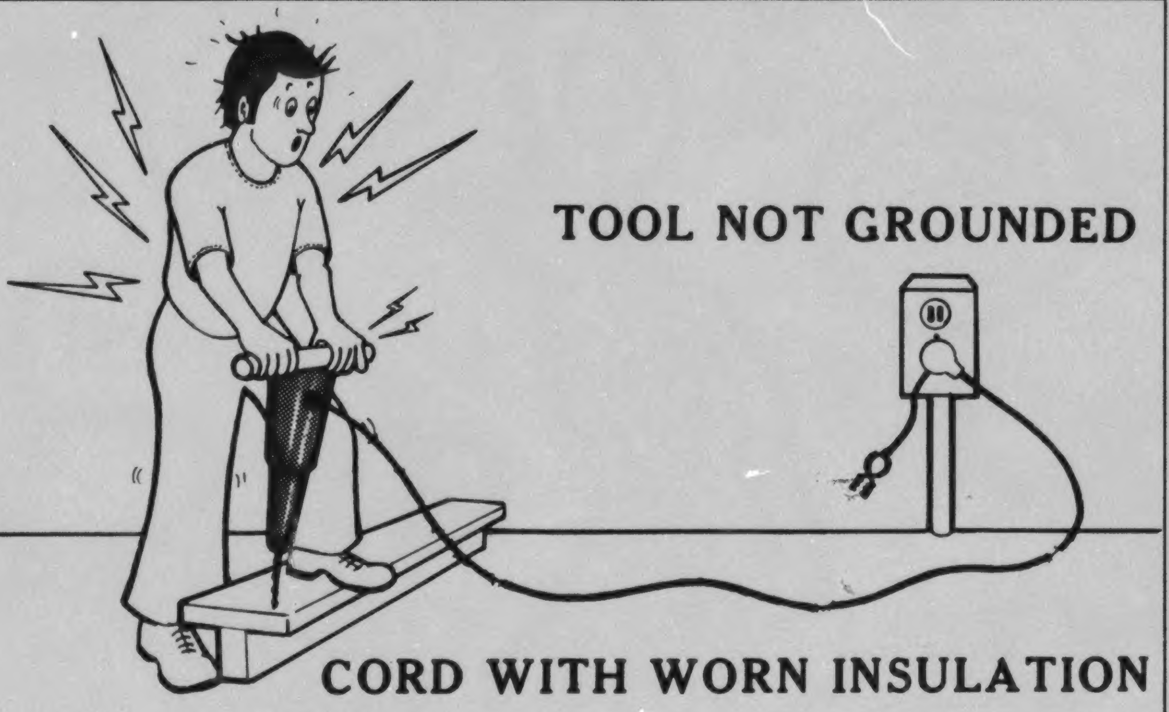


3-PRONGED OUTLET FOR GROUNDING TOOL

USE PLUG TO REMOVE CORD



DISCONNECT BY MASTER SWITCH



TOOL NOT GROUNDED

CORD WITH WORN INSULATION

GENERAL AGRICULTURAL MECHANICS

Unit O: Planning An Agriculture Safety Program

Topic 5: Agricultural Chemicals

Suggested Procedures and Activities: Samples of fertilizers, labels (pesticide), protective clothing, and available charts may be used during the class discussion as teaching aids.

Transparencies Nos. 1 and 2a

1. Introduction

   a. The safe use of chemicals is necessary in modern agricultural production. Without these chemicals, both quality and quantity of all produce and materials would be reduced. These chemicals are used to feed crop plants, and some are used to feed animals, control weeds, control insects, control the setting of fruit on trees, control soil reactions, and even to control moisture. Most of these chemicals can be used safely if used as recommended. They can also be very harmful if used improperly. Their misuse can cause death and injury to people, animals, and desirable plants.

   b. The two main chemicals that are used by the agriculturalist are pesticides and fertilizers. They may be defined as follows:

      (1) Pesticides - Materials (chemicals) used to destroy pests. The common types are: insecticides (insects), herbicides (weeds), fungicides (fungi), rodenticides (rodents), avicides (birds), and bactericides (bacteria). Of the two chemical groups, fertilizers and pesticides, it is a known fact pesticides cause more injuries, contaminate more water, and pollute more air than fertilizers, because most are considered poisonous.

      (2) Fertilizers - Materials to provide plants with nutrients needed for growth and fruit production. The two basic types are chemical (dry, liquid, and gaseous forms) and animal manures.

   c. The meaning of the term toxicity when referring to pesticides is: it is the degree of the poisonous effect to warm blooded animals. A pesticide label may be identified by the word Danger (highly toxic), Warning (moderately toxic), or Caution (low toxicity). The label of a highly toxic pesticide will show a skull with crossbones and carry the word 'Poison" which is printed in red. The ways toxic materials are taken into the body are:

(1) Oral -The poison is taken into the body through the mouth where it later passes to the digestive system. Oral exposure may be avoided by:

(a) Keeping pesticides in the proper containers with the proper label.
(b) Wait until the safety interval has passed before eating anything (vegetables, etc.) that has been sprayed. Post a sign in the vegetable area showing when it is safe to eat the produce.
(c) Thoroughly wash the hands and face with soap and water before eating.
(d) Refrain from smoking, chewing gum, or eating snacks while working with pesticides.
(e) Do not use the mouth to clean the low pressure nozzles or other parts of the equipment.

(2) Dermal - Actually absorbing pesticide through the skin can be more dangerous than taking it through the mouth. Absorption can take place when mixing, applying, or just handling a pesticide. It can also enter the skin by using contaminated clothing, drifting of dust or spray, and entering an area where reentry interval has not expired. Prevention of dermal exposure is:

(a) Eliminate splashing, spills, drift, reentry, and reuse of contaminated clothing and many dermal exposure problems are eliminated.
(b) Wear the proper type of clean clothing each day. Wash the tractor cushion if it becomes contaminated. It may even be necessary to change clothing more than once per day if the clothes become contaminated due to splashing or drift.
(c) Use below 50 psi when spraying and apply when the wind is less than 3 1/2 miles per hour.

(3) Inhalation - Inhalation exposure can be more dangerous with certain types of pesticides than others. Pesticide spray particles, vapors, and dust can be inhaled very easily under certain conditions. The three most common ways to inhale pesticides are smoking tobacco that has become contaminated, breathing smoke from burning pesticide material, and being in the drift during spraying or dusting. The ways to prevent inhalation exposure are:

(a) Use a chemical cartridge respirator that is equipped with dust filters and gas absorbing canisters.
(b) Refrain from smoking when working with pesticides and do not burn pesticide trash.
(c) When spraying or dusting operate the unit so that the drift will move away from the body, and do not spray or dust when the wind is above 5 miles per hour.

d. Some type of protective clothing should be worn when using or handling pesticides. Two types of clothes that are considered to give the best protection are water-repellent and coveralls that are heavy enough to keep out the pesticide. Always wear a long sleeve shirt. Coveralls should be changed daily. Complete clothing includes:

(1) Goggles - Wear goggles when handling pesticides. This includes mixing and loading. Use the unvented and nonfogging type. If a full face respirator is used, goggles are not needed.

(2) Gloves - Always use gloves when handling pesticides. Use long unlined rubber gloves. They can be washed easily. Use natural rubber gloves when handling organophosphates.

(3) Aprons - Wear a plastic or rubber apron long enough to cover the rubber boot tops when either mixing or loading pesticides. Rubber aprons should be used when mixing or loading organophosphates.

(4) Boots - Wear rubber boots when mixing, handling, and walking through freshly sprayed areas. Trouser legs should cover the boot tops.

(5) Respirators - Respirators are to protect against breathing pesticides. A gauge respirator can be used to filter out dust and spray particles. Cartridge respirators protect against gases and dust. Use a full-face respirator when working with highly toxic pesticides and working in close places. The respirator should be rinsed with soap and water after use.

e. It is very important that first aid be administered at first symptoms of poisoning and a doctor contacted. Remove contaminated clothing and wash the skin with soap.

(1) A synthetic organic pesticide may produce the following symptoms:

(a) Mild Poisoning - Headache, skin irritation, eyes, nose, and throat irritation, weakness, nausea, diarrhea, and dizziness.
(b) Moderate Poisoning - Poor muscle coordination, rapid pulse, blurred vision, flushed skin, stomach cramps, vomiting, and muscle twitches.
(c) Severe Poisoning - Convulsions, lack of ability to breathe, loss of consciousness, secretions from the mouth, and possible fever.

(2) First aid procedures for some types of exposure are:

(a) Eyes Affected - Wash the eyes by flushing with running water for about 15 minutes. Use low pressure and call a doctor.

(b) Skin Affected - Remove clothing and shoes. Wash the skin with soap and water. Use plenty of water. Call a doctor.

(c) Swallowed Pesticide - Check the type swallowed. It may be that the patient should be forced to vomit. Call for medical help immediately. If material is caustic or has a hydrocarbon solvent, vomiting must not be introduced. Use label instructions.

(d) Inhaled Pesticide - Have patient placed in fresh air. Keep patient quiet and warm. Loosen clothing and check for normal breathing. If breathing stops, apply artifical respiration. Get medical help immediately.

Transparency No. 2b

2. Storing Pesticides

A pesticide storage area (building or room) is needed on all farms, because the pesticide must be purchased before it is used and there may be a small quantity left for future use throughout the season. The storage area should be locked to prevent children, pets, and unwanted adults from entering. Warning signs should be placed on the walls and doors of the building or room. Suggestions for storing pesticides are:

a. Keep the pesticide in their original container and check to see that the label remains intact.

b. Place containers in small stacks. Broken packages let the material spill out and necessitate a decontamination program at the end of the season.

c. Store powder and granular pesticides on shelves to prevent caking. Caked material is very difficult to mix and it requires more handling. Some pesticides require warm locations in the winter. Freezing temperature may alter the chemical makeup.

d. Store insecticides apart from herbicides and completely away from a feed, seed, and other farm supply area.

e. Some pesticides contain flammable solvents; therefore, keep fire away from the storage room or building. Do not smoke in pesticide area.

f. Wear protective clothing when working in the storage area. The hands should be kept away from the eyes and mouth when handling pesticides in the storage area, even though the containers are sealed.

3. Disposing of Containers and Unused Pesticides

Usually each container contains a label explaining the best way to safely dispose of it. But usually they are kept at least a year before they are either burned, buried, or delivered to the scrap yard. Nearly all containers have some hazardous pesticide material left in them, even if they are supposed to be empty. Containers may be divided into the following three groups for disposal purposes:

a. First Group - Containers that were not used for lead, arsenic, mercury, or cadmium compounds and will burn. They may be burned in a pesticide incinerator or open fire.

b. Second Group - Containers that held pesticides in the first group but made of material that will not burn. This type container may be rinsed, returned to supplier, delivered to a scrap metal dealer, or crushed and buried.

c. Third Group - Containers that held inorganic pesticides or mercury, arsenic, cadmium, or lead. Rinse three times and bury in a landfill. Also bury rinse water in a pit. Usually containers and water are buried at least 18 inches deep.

4. Fertilizers

The hazards in handling fertilizer are usually not considered as dangerous as handling pesticides, although such fertilizers as anhydrous ammonia and aqueous ammonia should be handled with extreme care. Animal manures can also cause problems if certain safety practices are not observed.

a. Safety practices to observe when working with solid or dry fertilizers are:

   (1) When filling hoppers, stand on the upwind side to prevent the dust from blowing and settling on uncovered or unprotected places of the body.

   (2) Pull a full open fertilizer distributor crosswind in the field. Dust will be blown off one side instead of toward the tractor operator.

   (3) Do not check the spreader by leaving the spinner mechanism in motion and walking to the rear of the machine. Fertilizer dust and larger particles can injure the entire face, especially the eyes.

Solid fertilizer is a hygroscopic (attracts moisture); therefore, it has a tendency to remove moisture from the skin, leaving it dry. Fertilizer dust may irritate the eyes, mouth, ears, and scalp. It may also irritate the lungs if breathed in closed places or breathed for a short time where the dust is heavily concentrated. Protective measures to use while handling dry fertilizer are: wear as much covering on the body as possible (cap, long sleeve shirt, in some cases gloves); wash and bathe by using soap and water; change clothes daily when working with fertilizers; and use a respirator if necessary.

b. Precautions to observe when handling anhydrous ammonia include:

  (1) Use the proper equipment for anhydrous ammonia. It is handled as a pressurized liquid; therefore, all tubes and fittings must be tight and strong.

  (2) Check and replace pressure relief valves if they fail to function properly, replace worn or cracked hoses, and keep the tank painted with white paint made for ammonia tanks.

  (3) Anhydrous ammonia is considered nonflammable, but under certain conditions it could ignite. The fire is controlled as a flammable gas.

  (4) When transferring anhydrous ammonia, wear unvented, tight-fitting goggles and rubber gloves. Affected clothing should be removed and the skin washed. A federal law requires that at least five gallons of fresh water be available on vehicles transporting anhydrous ammonia. A plastic squeeze bottle is recommended for treating the eyes.

c. Precautions to observe when working with aqueous ammonia:

  (1) Exposure to aqueous ammonia is similar to being exposed to anhydrous ammonia. It can cause severe burns and produce a very strong choking odor; therefore, work on the upwind side and drive crosswind when spraying the fertilizer on the field.

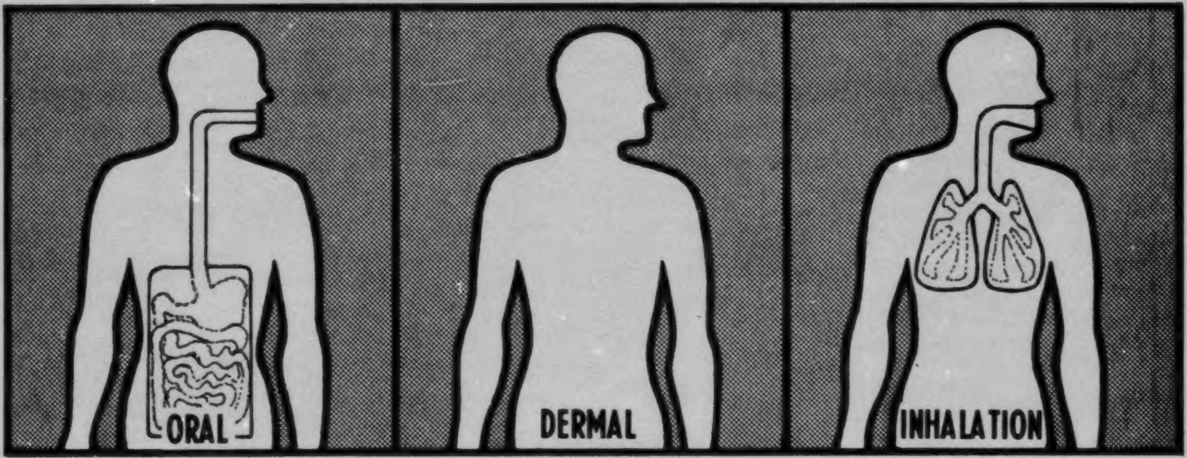
  (2) Aqueous ammonia is a solution of water and anhydrous ammonia, which means that it is not usually stored or transported under pressure. However, closed (air tight) spray tanks can be dangerous if exposed to direct sunlight. Park the tank under a shade when not in use. Also keep the tank painted white with a paint recommended for that purpose.

References:

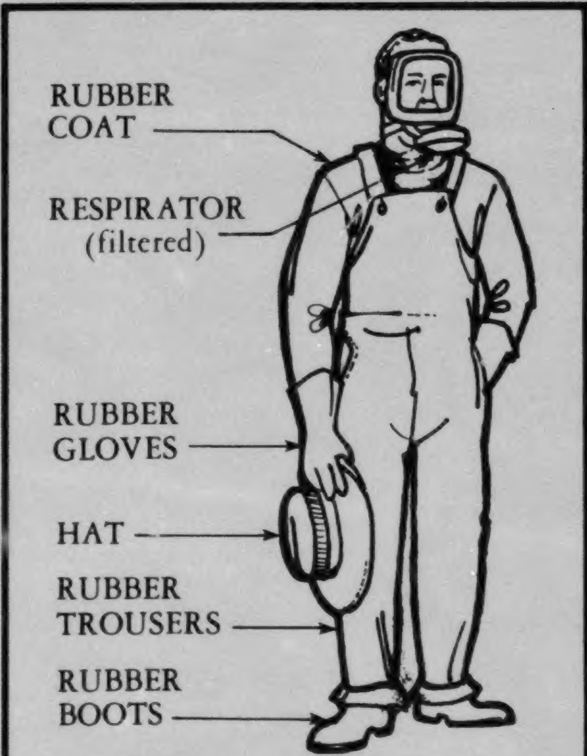
1. "Fundamentals of Machine Operation, Agricultural Machinery Safety", Deere and Company, Moline, Illinois, 1974

2. "Applying Pesticides - Management, Application, Safety", American Association for Vocational Instructional Material, Athens, Georgia, 1976

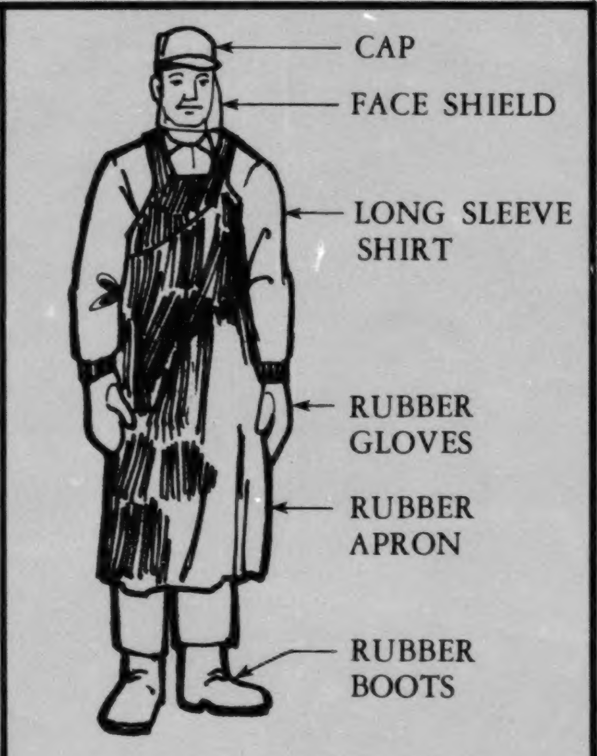
AGRICULTURAL CHEMICALS


ORAL
DERMAL
INHALATION

EXPOSURE DANGER


RUBBER COAT
RESPIRATOR (filtered)
RUBBER GLOVES
HAT
RUBBER TROUSERS
RUBBER BOOTS

WORN FOR MOST PESTICIDES

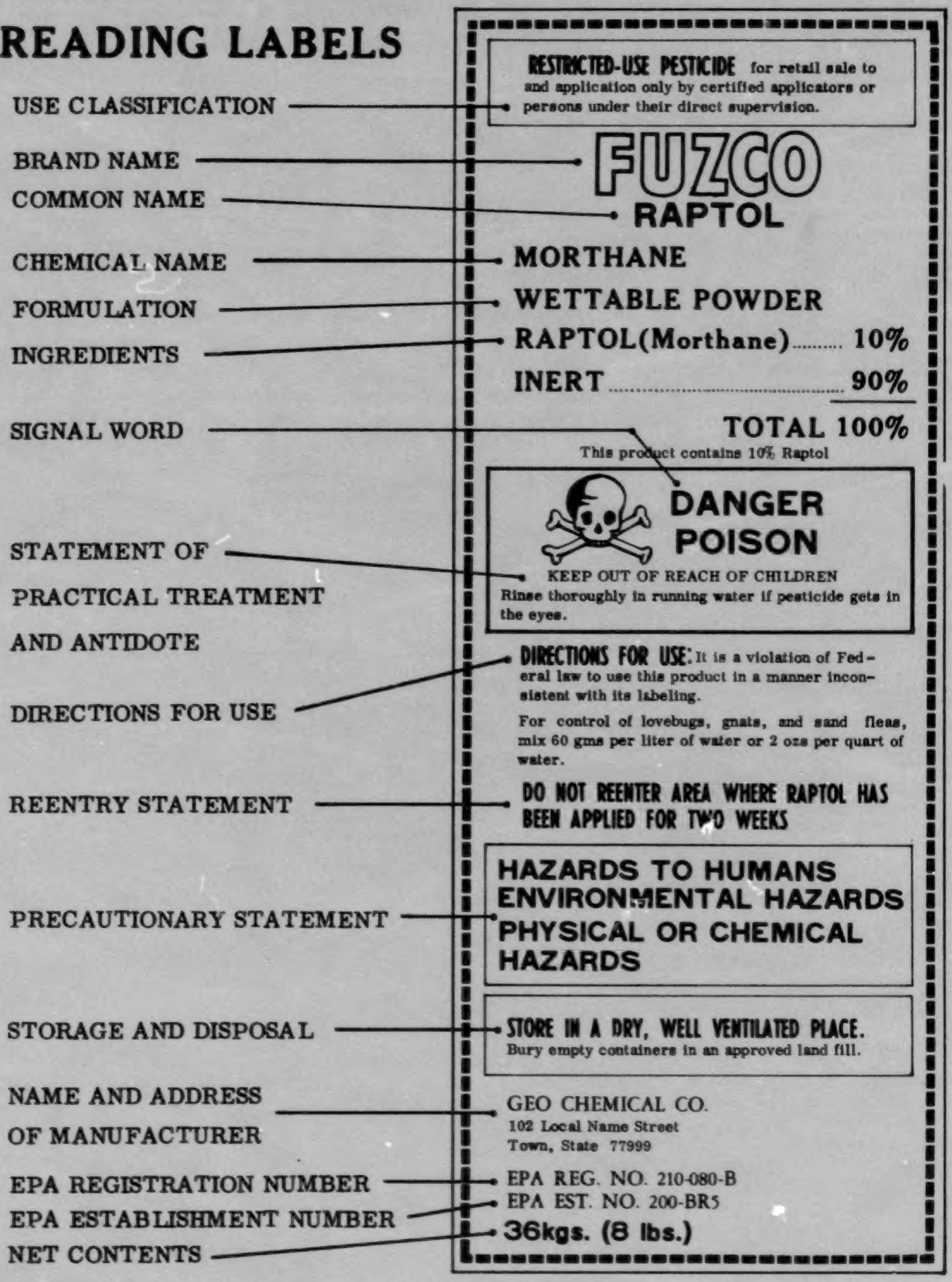

CAP
FACE SHIELD
LONG SLEEVE SHIRT
RUBBER GLOVES
RUBBER APRON
RUBBER BOOTS

WORN FOR AQUEOUS AMMONIA

PROTECTION

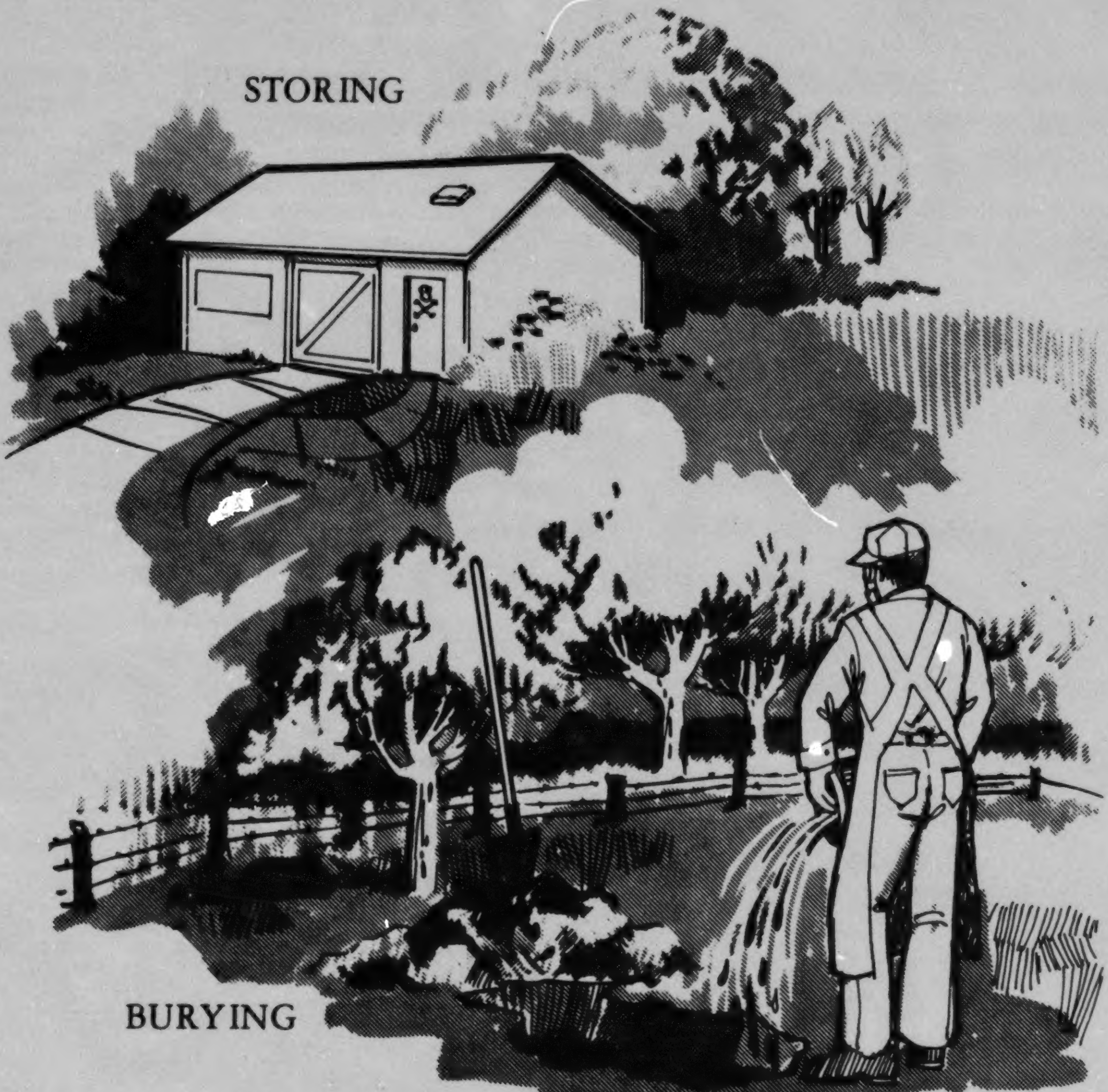
SAFETY PRACTICES-PESTICIDES

READING LABELS



USE CLASSIFICATION	**RESTRICTED-USE PESTICIDE** for retail sale to and application only by certified applicators or persons under their direct supervision.
BRAND NAME	FUZCO
COMMON NAME	RAPTOL
CHEMICAL NAME	MORTHANE
FORMULATION	WETTABLE POWDER
INGREDIENTS	RAPTOL(Morthane) .... 10% INERT .... 90% TOTAL 100% This product contains 10% Raptol
SIGNAL WORD	DANGER POISON
STATEMENT OF PRACTICAL TREATMENT AND ANTIDOTE	KEEP OUT OF REACH OF CHILDREN Rinse thoroughly in running water if pesticide gets in the eyes.
DIRECTIONS FOR USE	**DIRECTIONS FOR USE:** It is a violation of Federal law to use this product in a manner inconsistent with its labeling. For control of lovebugs, gnats, and sand fleas, mix 60 gms per liter of water or 2 ozs per quart of water.
REENTRY STATEMENT	**DO NOT REENTER AREA WHERE RAPTOL HAS BEEN APPLIED FOR TWO WEEKS**
PRECAUTIONARY STATEMENT	HAZARDS TO HUMANS ENVIRONMENTAL HAZARDS PHYSICAL OR CHEMICAL HAZARDS
STORAGE AND DISPOSAL	**STORE IN A DRY, WELL VENTILATED PLACE.** Bury empty containers in an approved land fill.
NAME AND ADDRESS OF MANUFACTURER	GEO CHEMICAL CO. 102 Local Name Street Town, State 77999
EPA REGISTRATION NUMBER	EPA REG. NO. 210-080-B
EPA ESTABLISHMENT NUMBER	EPA EST. NO. 200-BR5
NET CONTENTS	36kgs. (8 lbs.)

SAFETY PRACTICES- PESTICIDES


STORING
BURYING

DISPOSING OF PESTICIDE MATERIAL

Vocational Instructional Services

Gen. Ag. Mech.

935-O-5
No. 2b

GENERAL AGRICULTURAL MECHANICS

Unit P: Planning and Organizing the Farm Shop

Topic 1: Farm Shop

Note: The information in this topic pertains to the planning and organizing of a farm shop, but much of the materials should be useful in planning other types of shops and buildings. A well-organized and adequately planned building requires considerable time, but the investment in planning time is returned many times in the form of convenience, labor savings, and cash savings.

1. Introduction

A farm shop can be put to many uses, such as the repairing and maintaining of machinery, equipment, farm buildings, plumbing; and the constructing of storage, new equipment, and buildings. A well-equipped shop can increase the life of machinery and equipment, aid in distributing hired labor, serve as a farm office, provide work during inclement weather, increase the hours of operation of machinery and equipment during the busy seasons, and reduce repair and maintenance time.

Farmers' and ranchers' investments in machinery and equipment have doubled in a relatively short period of time. As machinery is continually being used to replace labor, it is expected that their investments will continued to increase.

Most farmers and ranchers can readily justify the construction of a building or the renovation of an existing building for a farm shop. The question that most often needs to be answered is how much space and expense can be justified for a building, equipment, and tools. Building and equipment needs will depend upon the type of farming operation; investment in equipment; skills possessed by owner, manager, or hired help; availability of financing; availability of tools and equipment; and owner's desire to provide building and equipment for shop.

Although numerous decisions must be made in planning the farm shop, it is felt that the planning sequence given below will provide one with much of the information needed to make good planning decisions.

2. Selecting the Site

An ideal situation would be to select a site and plan a new structure for the site, but this is not always possible. It may be necessary to convert an existing building into a farm shop; however, the same planning procedure, with the exception of site selection, can be used.

Considerations in selecting a site are as follows:

1. Location of existing or proposed equipment storage shed. It is more convenient and will save labor if the shop building is located next to or adjacent to the equipment storage shed. Equipment needing repairs may be protected from the weather until repairs are made, and minor repairs can often be made without moving the equipment. Also, tools are conveniently located for making adjustments to equipment before beginning its operation.
2. Location of utilities. Electricity and water are a necessity for the shop and must be available to the site. If a part of the shop building will be used for an office, telephone service also should be available.
3. Location of all-weather roads. For maximum utilization, the shop must be accessible during all kinds of weather.
4. Source of heat for the shop. In order to use shop during cold weather, a source of heat will be needed. A thermostatically controlled forced draft gas heater is ideal.
5. Area around shop. Space will be needed for parking vehicles and equipment. Large equipment requires a minimum of 50 feet turning space.
6. Site location in relation to residence and other buildings. It is difficult to keep the area around a shop from having a cluttered appearance; therefore, it should be shielded with plants or other buildings from the residence and public roads. The shop building and surrounding area should not detract from the farmstead. The shop location also should not present a fire hazard to stored crops and other buildings.
7. Traffic pattern. A study of the equipment traffic pattern will aid in selecting a site that is convenient to the movement of equipment. A site near the harvest equipment traffic is often the most convenient.

After selecting the site, the planner is ready for the next phase, which is discussed below.

3. Determining Tool and Equipment Needs

Few farmers are financially able to purchase all of the tools and equipment needed in the farm shop at one time, and their purchase may have to be spread over a period of time. Nevertheless, the tools and equipment to be used in the shop will influence the size of shop, method of storing tools, and structural design of building.

Tool and equipment requirements can be determined by compiling a list of all of the uses or jobs to be performed in the shop. These will vary from one farm to another. Some uses are presented below:

1. Servicing, maintaining, and repairing equipment and machinery (This may include tractors, trucks, cultivation equipment, trailers, sprayers, combines, and haying equipment.)
2. Constructing and repairing new and used equipment (metal and wood)
3. Maintaining and repairing of farm structures
4. Tool storage
5. Material storage (metal, lumber, etc.)
6. Supply storage (parts, bolts, nails, etc.)
7. Farm office

The next step (No. 2) is to categorize or classify the shop uses into shop areas. Using the above uses as an example, the shop would probably have the following areas:

1. Metalworking
2. Machinery repair
3. Woodworking
4. Storage for plumbing and masonry tools
5. Office

In step 3, a list of tools and equipment to be used in each area is compiled. It is suggested that two lists be compiled, one list for hand tools and one for larger tools and equipment.

The student in General Agriculture Mechanics should not experience difficulty compiling the lists. However, the "Facility Standards and Equipment for Agriculture Education Programs" and a farm catalogue published by one of several large retail firms might be helpful in making the lists. The following is a partial list of large equipment and a suggested format that may be used. The reason for including floor and passage spaces on the tool list is explained later.

Metalworking Equipment List

Item	Description	Quantity	Floor Space Requirement	Passage Space
Anvil	Blacksmith, Steel Face, 150#	1	2' x 2½'	3'
Bench	Metalworking, Shop made	1	2½' x 4'	3'
Grinder	Pedestal, 1hp. Elec. Motor w/10" wheels	1	24" x 28"	3'
Hoist	Chain, 1½ ton W/A Frame, Portable	1	2' x 6'	-
Table	Welding and Cutting (shop made)	1	2½' x 4'	3'
Vat	Water (half barrel)	1	2' x 2'	2'
Welder	Electric Arc, 250 volts	1	22" x 28"	3'
"	Oxy-acetylene, All equip.	1	20" x 24"	3'

Below is a partial list of hand tools that might be used in the metalworking area:

Metalworking Hand Tools

Item	Description	Quantity
Hammers	Ball pein, ½ lb., 1 lb., 2 lb., each	1 (Total 3)
"	Chipping (for welding)	2
"	Machinist, 2½ lb.	1
Pliers	Battery, 8"	2
"	Combination, 8" or 10"	2
"	Vise grip (for welding)	2
Punches	Center, 3/8" and 1/2", each	2 (Total 4)
Screw drivers	Cabinet, 3" to 6", round shank	2 sets

After the equipment and hand tool lists have been completed for each area, two other areas should be considered. These are the service area and the area for miscellaneous tools.

A decision should be make at this time as to whether machinery and equipment repairs will be made on the inside or outside of the shop building. Both locations for the service area have some advantages. If repairs to machinery and equipment are to be made inside the shop building, space requirements for the service area must be determined. This is accomplished by measuring the largest piece of equipment that will be serviced or repaired in the building. Three feet should be added to the measurements to allow for passage, for the movement of tools and equipment, and for working on the machinery. When equipment is not being repaired, this space can be used for constructing and repairing new and old equipment.

The service area outside of the building also requires planning time. Factors such as whether to provide a covered service area, the hard surfacing of the service area, and location of service area are considered.

The next step, No. 4, is to compile a list of miscellaneous tools. The same format as used for metalworking equipment is suggested, and the floor and passage space for each tool should be noted.

After the equipment and hand tool lists have been compiled, the planner is ready for the next phase, which is discussed below.

4. Determining the Size of the Shop Building

The steps suggested for determining shop building size are listed in sequence.

1. Measure each piece of equipment to be placed in the shop building to determine the amount of floor space it requires. This includes the equipment that will be used in all areas. As the space determinations are made, they may be recorded on the equipment list. The format used for listing metalworking tools provides space for recording these measurements.
2. Determine the amount of passage, clearance, and working space needed in front of or around each piece of equipment. This is listed as passage space on the form used for listing metalworking equipment.
3. Determine method (s) that will be used to store hand tools and the amount of floor space required for their storage.

Transparency No. 1

Three methods are commonly used for storing hand tools. These are the open wall board (peg board or other materials), wall cabinet, and portable dolly. If a dolly is used, the amount of floor space used by the dolly must be determined, as well as the other storage methods. The dolly is convenient for tools used in several locations in the shop. Open wall boards are inexpensive and easy to construct. Wall storage cabinets require less wall space, as tools are stored in the doors as well as in the back of the cabinet. The cabinet can be locked to provide a measure of security for tools. Regardless of the method used, the drawing of a silhouette of each tool at its storage site will facilitate the retrieval and replacement of tools.

Transparency No. 2

Methods of storing miscellaneous tools, supplies, and materials are shown in the above tranparency. Inflammables such as gasoline, oil, and other fuels should be stored in another location and some distance from the shop building.

4. The amount of floor space required by equipment, hand tools, storage, and miscellaneous equipment is determined. The total should be checked for accuracy.
5. The amount of floor space required for passage, clearance, and working is determined. Again, the total should be checked for accuracy.
6. Add the totals in steps four and five to the floor space needed for the service area; that is, if the service area will be inside the shop building.

The addition of these totals should provide a fairly accurate estimate of the floor space needed in the building.

7. A piece of poster board is secured. The poster board should be 22" x 28" if a large shop is planned, while an 18" x 22" poster board is adequate for a small shop.

Transparency No. 3

8. Horizontal and vertical lines are drawn ½ inch apart across the poster board. This will give a scale of ½ inch equal one foot. Since some of the equipment is usually rather small, this is the recommended scale. However, other scales may be used. The number of feet each line represents is designated on the poster board.
9. A template (pattern cut from paper) of each piece of equipment, the service area, and other items requiring floor space is cut to scale. As each template is cut, it is labeled and floor space and passage measurements are recorded on the template. An arrow is drawn on the template pointing to the side (s) where passage space is required. This serves as a reminder to allow for passage space when the equipment arrangement is considered in a later step.
10. The shop arrangement is determined. The planner is now ready to experiment with the arrangement of equipment and other items. Several components, however, should be considered before beginning to make the arrangement.

For the orderly movement of equipment, the building entrance and exit (entrance and exit may be the same) should be adjacent to the service area. Since many of the service jobs require the use of metalworking tools, the metalworking area and the service area should be located near each other. It is advised that these areas be planned first. Now, the planner is ready to experiment with the shop arrangement.

The following steps may be used to determine the arrangement.

Transparency No. 4

1. The location of service area and entrance are determined. The service area template is placed on the poster board and moved to several positions. The entrance must open onto the service area. The decision as to their locations may be made simultaneously. The service area should not be located next to a wall. A minimum of three feet must be left between wall and service area. If a separate exit is going to be used, it normally will be opposite the entrance. The templates are temporarily fastened in place.
2. Metalworking equipment is arranged. The templates of the metalworking equipment are arranged on the poster board, are given a permanent location, and are temporarily fastened in place.

   Many of the tools in the metalworking and other areas in the shop can be mounted on casters. This will allow equipment to be moved easily, increase the floor space in an area, and permit the construction of a smaller shop building.

The arc welder and the cutting torch should be located near entrance. This permits their use outside of the shop. Attention is directed to the arrangement of the metalworking area in transparency No. 4.

3. Equipment and tools in other areas are arranged. The templates of the equipment to be used in other areas are arranged in the same manner. By planning these areas in the order of their importance allows the planner to reduce the amount of floor space in the shop if it becomes necessary.

   If possible, the wordworking area also should be located near the service area. The service area at times may be used to construct or repair items made from wood.

   Convenience is the major consideration in arranging miscellaneous items, such as an air-compressor. A place near the main entrance is a good location for items that will be used outside of the shop building.

   Material and supply storage and office space should not be overlooked.

   After all templates are placed on the poster board, all measurements and dimensions are checked for accuracy.

4. The dimensions of the shop are determined and entered on the poster board.

5. Building Types and Materials

Roof Structure - Any of several types of roof structures may be used, but the two most common and least expensive are the gable and shed. The roof must be high enough to permit the entrance of the tallest piece of equipment, if the service area is inside the building.

Construction Materials - The use of arc or oxyacetylene welders in the shop limits the materials that may be used to those that are not inflammable. Cinder or concrete blocks, metal siding, bricks, and tile are materials that may be used.

Doors - A minimum of 10 feet wide is recommended for the door (s) to the equipment entrance. They may be of the overhead or two-section, outside sliding types. The installation of two, three-feet wide, personnel doors is recommended. One personnel door is normally located next to or within the equipment entrance door (s), while the other is located on the opposite end or side wall of the building. This gives another exit in case of fire.

Windows - These are necessary for lighting and may be used for ventilation. At least two walls should have windows; their location should provide uniform natural lighting.

Floor - The minimum thickness of concrete recommended is four inches. It may be necessary for the floor to be thicker, particularly if extremely heavy equipment will enter the building.

Water - This provides fire protection and is necessary for servicing equipment and for washing hands after work. Two faucets are needed, as one is connected at all times to a garden hose for fire protection.

Heating Equipment - A source of heat is necessary if work will be performed during cold weather. A thermostatically controlled, forced air heater is ideal, but other equipment may be used. An outside vent is required for most heating equipment.

Electrical Entrance Panel and Electric Wiring - The entrance panel should provide enough circuits for lighting, electric motors, convenience outlets, and arc welder to be placed on separate circuits. Electric welders require three-wire, 240 volt, single phase service. A three-wire polarized convenience outlet should be located near the equipment entrance and near each electric motor under one-half horsepower. A separate fuse and a three-wire polarized outlet should be provided for each electric motor larger than one-half horsepower.

The rule of thumb for artifical lighting is one 300-watt bulb for each 100 square feet of floor area. The use of several electrical switches will conserve electricity by permitting the use of lights only in the area being used. Outdoor lights at the equipment entrance and personnel doors are an added convenience.

Transparency No. 5

Ventilation - A system of ventilation is necessary when welding or running gasoline engines with the doors and windows closed. A vent or a vent having an exhaust fan can be installed over the welding and cutting table to remove fumes. A metal flexible tube vented to the outside may be used to remove carbon monoxide gas produced by combustible engines. If the shop building is arranged to take advantage of the prevailing wind, an exhaust fan mounted in the gable of one end of the building can be used as ventilation. The fan should be large enough to move one cubic foot of air per minute for each square foot of floor space in the shop. This system will not eliminate the need for a ventilator hood over the cutting and welding area.

6. Tool Inventory and Identification

Shop equipment and tools represent a considerable investment and should be included in the annual farm inventory. In addition, tools and equipment can be depreciated on the income tax. A record will be needed, however, if depreciation is taken.

Several methods may be used in making the inventory; however, it is suggested that all equipment be placed on one inventory form and that hand tools be inventoried on a different form. An example of a five-year inventory form appears below.

SHOP INVENTORY

Equipment

Item	Description	Years - Indicate Number on Hand				
		19	19	19	19	19

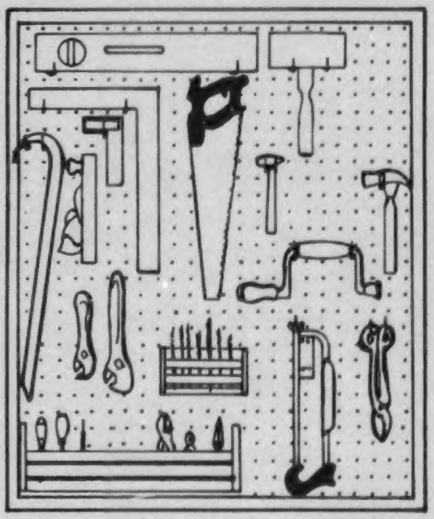
It might be advantageous to mark tools in the shop to prevent hired help from mistaking them for theirs and for identification in case they might be stolen. A permanent mark of identification can be applied with an electric engraver or steel letter stamps.

References:

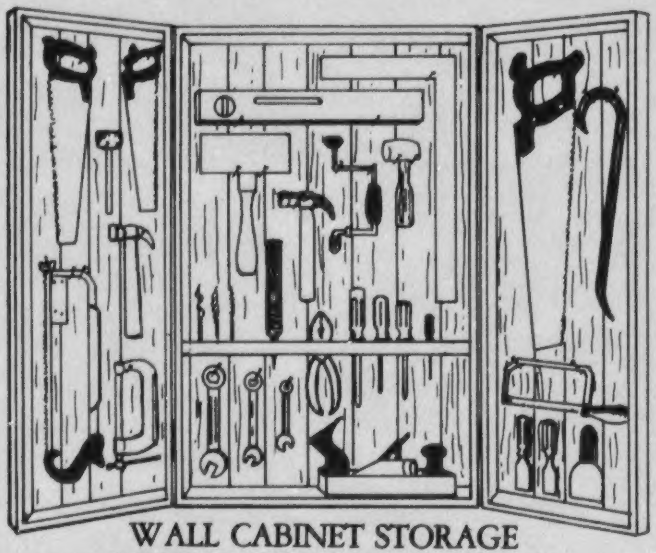
1. Phipps, Lloyd J., Mechanics in Agriculture, The Interstate Printers and Publishers, Inc., Danville, Illinois, 1967

2. "Shop Planning", American Association for Vocational Instructional Materials, Athens, Georgia, 1975

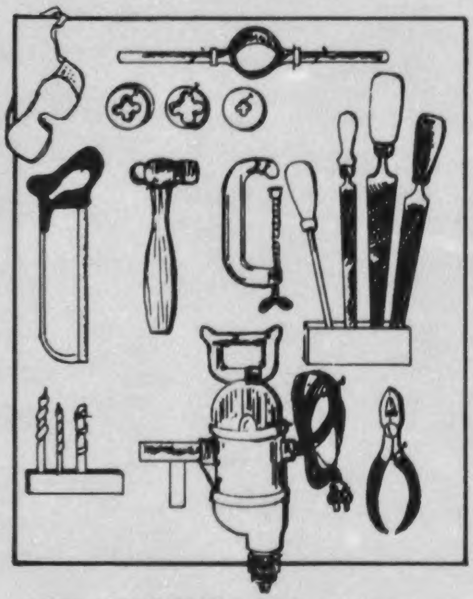
STORING HAND TOOLS



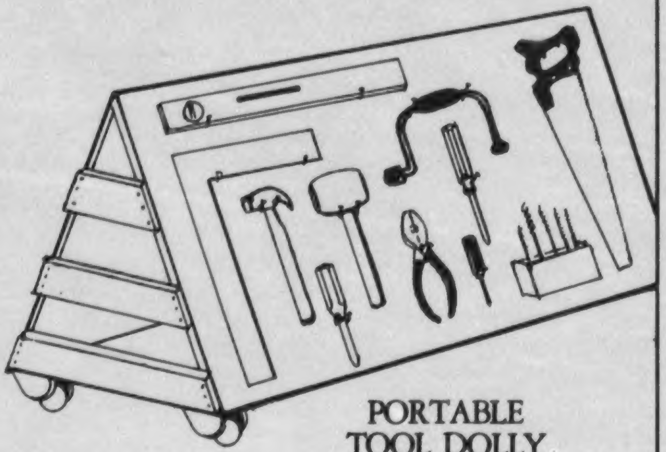
OPEN WALL STORAGE OF WOODWORKING TOOLS ON PEGBOARD



WALL CABINET STORAGE OF WOODWORKING TOOLS

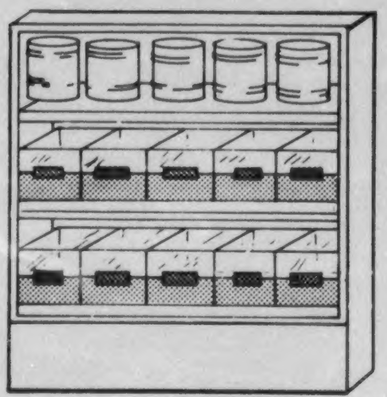


OPEN WALLBOARD STORAGE OF METALWORKING TOOLS

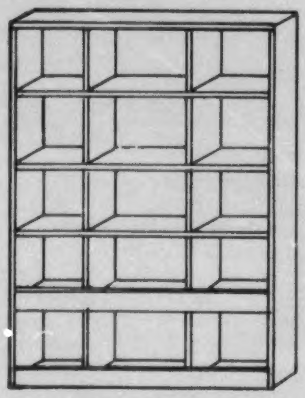


PORTABLE TOOL DOLLY

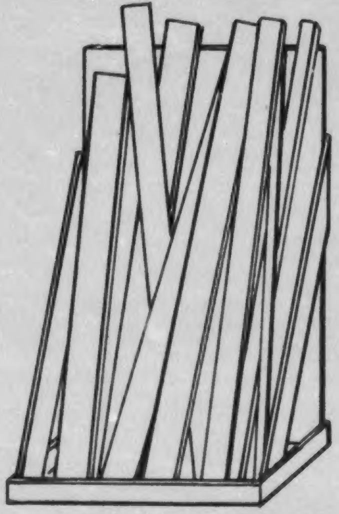
MISCELLANEOUS STORAGE



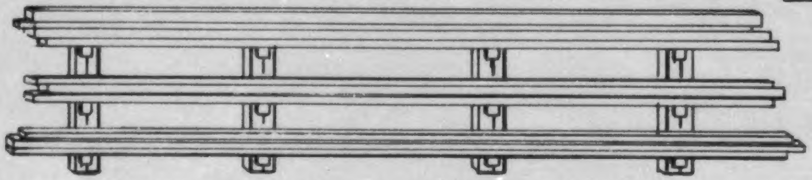
BOLTS, NUTS, SCREWS & NAILS STORAGE



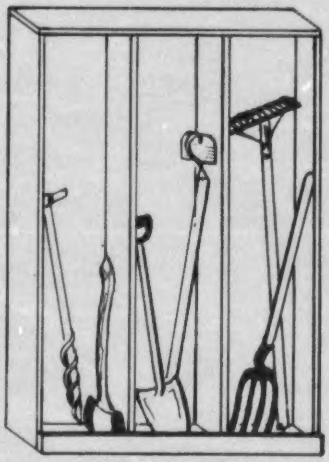
PARTS STORAGE



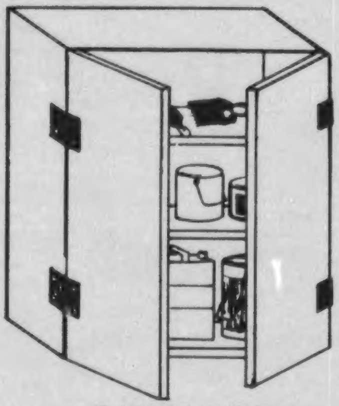
VERTICAL LUMBER STORAGE



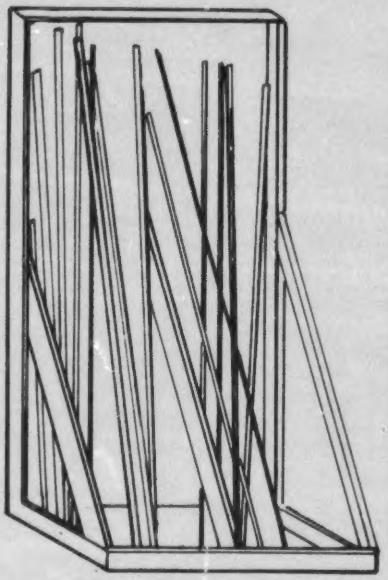
HORIZONTAL LUMBER STORAGE



GARDEN & FENCING TOOL STORAGE

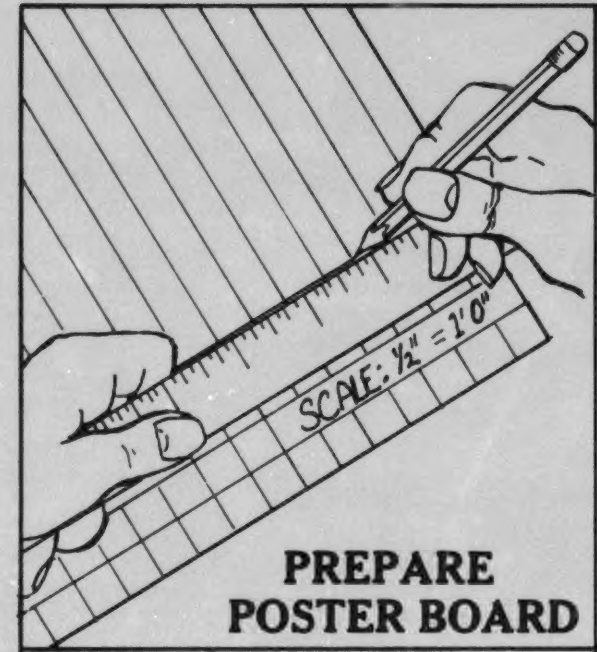


PAINT SUPPLY STORAGE

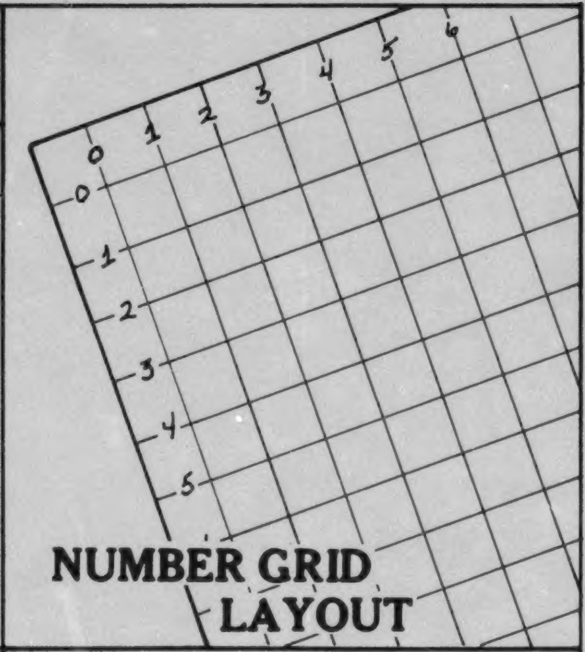


VERTICAL METAL STORAGE

PLANNING WORK AREAS

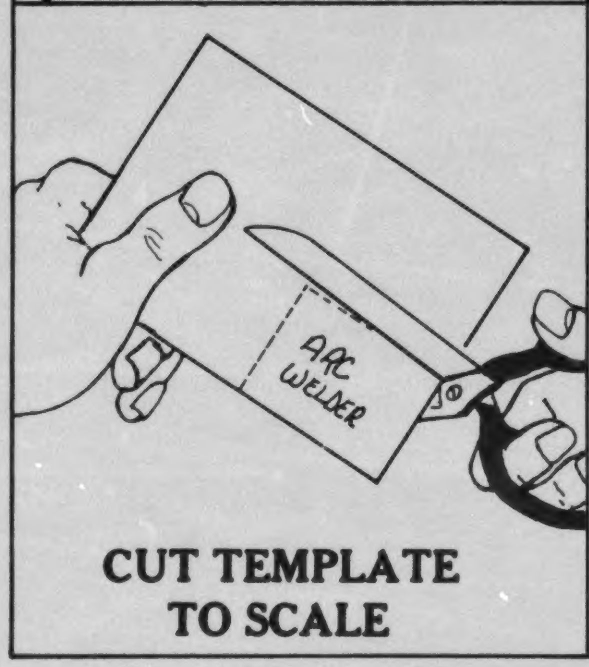


PREPARE POSTER BOARD

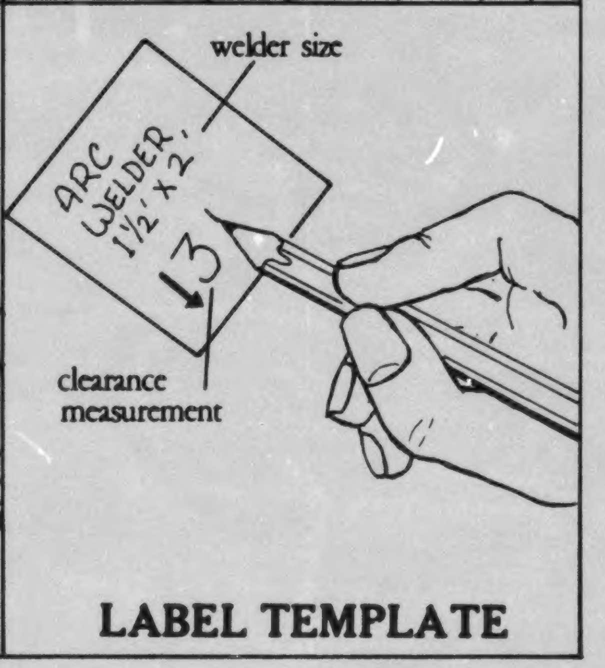


NUMBER GRID LAYOUT

0
1
2
3
4
5
6
0
1
2
3
4
5



CUT TEMPLATE TO SCALE

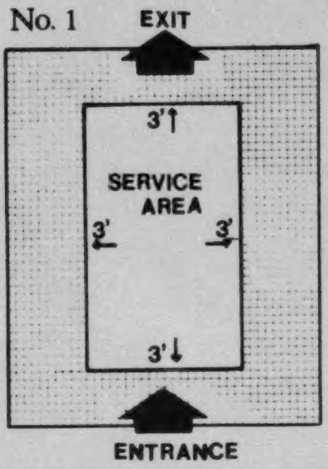


LABEL TEMPLATE

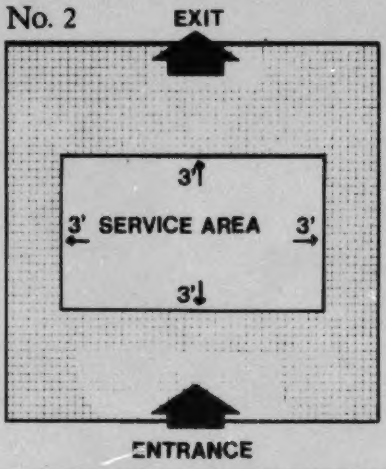
welder size
ARC WELDER 1½' x 2'
3
clearance measurement

PLANNING WORK AREA

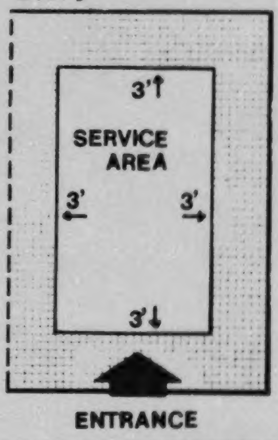
No. 1

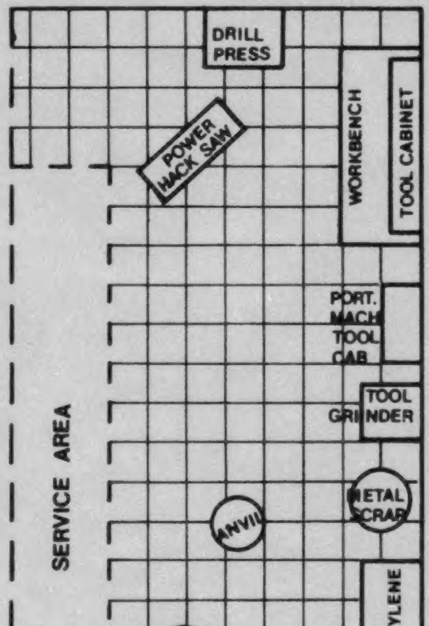

EXIT
3'
SERVICE AREA
3'
3'
3'
ENTRANCE

No. 2

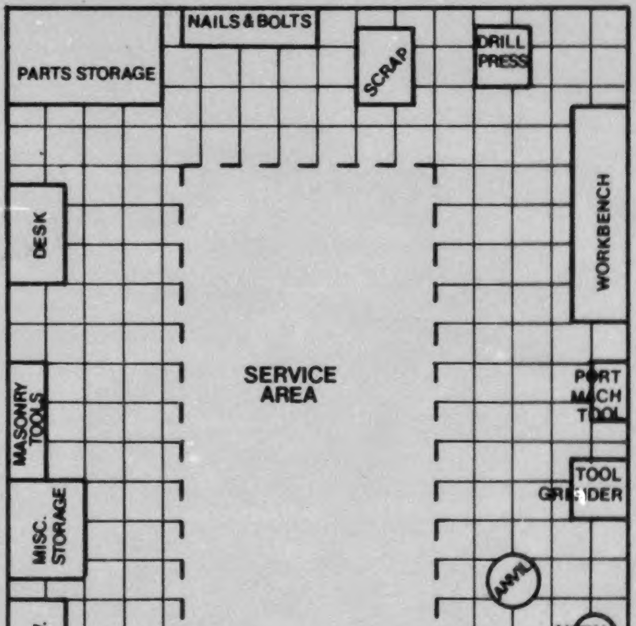

EXIT
3'
3'
SERVICE AREA
3'
3'
ENTRANCE

No. 3


3'
SERVICE AREA
3'
3'
3'
ENTRANCE

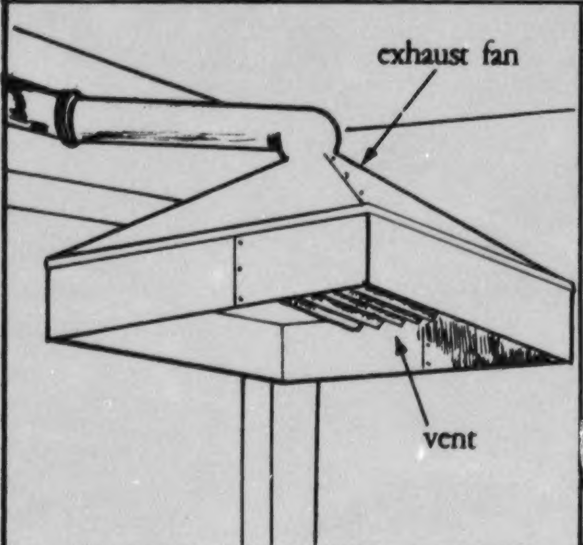

DRILL PRESS
POWER HACK SAW
WORKBENCH
TOOL CABINET
PORT. MACH TOOL CAB
TOOL GRINDER
SERVICE AREA
METAL SCRAP
ANVIL
OXY-ACETYLENE
WATER VAT
ARC WELDER
COMB. WELDING TABLE
STORAGE

METALWORKING AREA

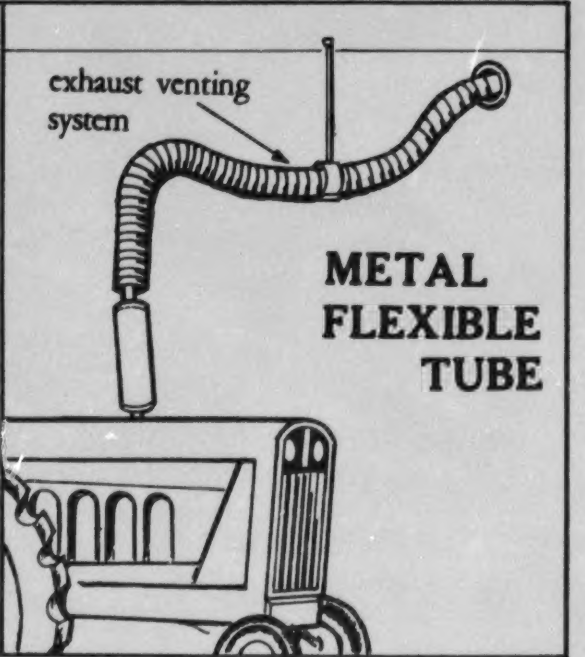

PARTS STORAGE
NAILS & BOLTS
SCRAP
DRILL PRESS
DESK
WORKBENCH
SERVICE AREA
PORT MACH TOOL
MASONRY TOOLS
TOOL GRINDER
MISC. STORAGE
ANVIL
LAV.
METAL SCRAP
PORT AIR COMP.
FIRE EXT
ARC WELDER
WELDING TABLE
STORAGE

TOTAL WORK SPACE

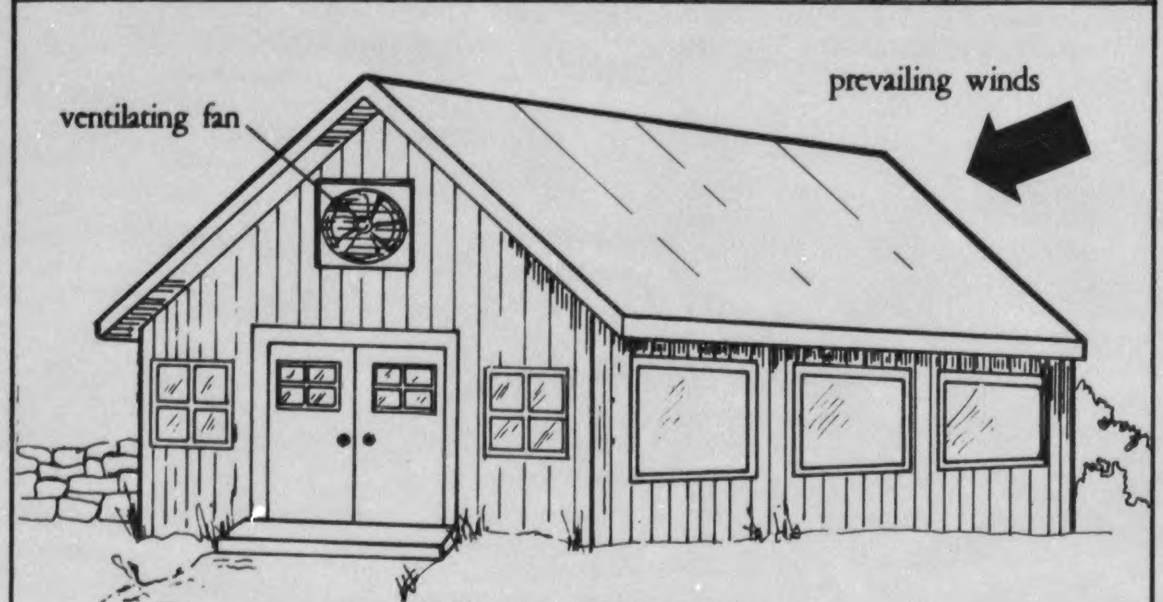
VENTILATION EQUIPMENT


exhaust fan
vent

HOOD VENTILATOR WITH EXHAUST FAN


exhaust venting system

METAL FLEXIBLE TUBE


ventilating fan
prevailing winds

EXHAUST FAN

GENERAL AGRICULTURAL MECHANICS

Unit Q: Farm Structures

Topic 1: Planning and Constructing Buildings and Equipment

Note: Several options are available to the farmer who plans to build a farm structure. Blueprints and the bill of materials may be prepared by an architect, a carpenter, contractor, or the farmer. The building of a structure may be contracted, or certain parts of the structure may be subcontracted, or the entire structure may be built by the farmer.

The information in this topic is directed to the owner-builder, who will prepare the plans, figure the bill of materials, and contruct the structure. A review of the topic, "Planning and Organizing the Farm Shop" should be helpful in planning the farm structure.

1. Building and Equipment Plans

Detailed plans and blueprints are very important, for they determine the cost, affect the quality of work, and save time. Considerable time and effort must be expended in the planning of a structure if it is going to meet the needs for which it was intended. Because of the rapid changes in cultural and production methods, immediate as well as long-term needs must be considered. Since it is difficult to anticipate future uses and needs, many farmers construct utility buildings, which can be remodeled with a minimum of change to the structure.

Using the following steps should be helpful in making the plans and determining the size of structure to build:

1. Prepare a list of present and future uses of the structure. Immediate needs should be given precedence over probable long-term needs. The builder may wish to plan the structure so that an addition can be constructed to meet future needs.
2. The amount of floor space required for each use is determined. Some uses might be the storage of crops, equipment, vehicles; protection for animals; and a farm shop.
3. A list of the equipment to be used in the structure is compiled. Space must be provided for equipment. Also, passage space around equipment must be considered when determining the size of the structure.

4. Total floor space needs are determined.
5. Review plans and blueprints of several different types and kinds of structures used for similar purposes. The builder may wish to observe some of the better farm buildings in the area in which he lives.
6. The type of construction is determined. A discussion of the types of construction is included in this topic.
7. Prepare or secure a detailed blueprint and accurate bill of materials.
8. Select a building site. Convenience is of primary importance in selecting a site. A study of the farm vehicle traffic pattern may be helpful. The utilities that will be needed at the site should also be considered.

II. Types of Construction

There are many different roof types, building materials, and construction procedures that may be used in building farm structures. Some of the factors to consider in making decisions related to these items are discussed.

Transparency No. 1

ROOF TYPES. Some of the roof types used on farm structures are shown in the above transparency. The shed and gable roofs are the most common. The shed roof usually is entered from one side, the side having the most clearance; therefore, this type of roof is generally not used for a building where equipment will be driven through the building.

Unless doors are installed on the front, equipment and other stored items may not be protected from blowing rain and snow. If the building is to be free of center posts and have a wide span, another type of roof should be used. The maximum recommended distance between posts or studs on a shed roof is 18 feet.

Longer spans will not provide the strength needed for the roof to withstand wind pressure or snow.

Buildings having gable roofs may be entered from the sides and/or ends and are particularly adapted for through vehicle traffic. Extremely tall equipment may enter at the ends of a gable roof building, if the rafters or trusses have been constructed to provide the needed height. If rafters are used, the recommended span of a gable roof is 24 feet, while the building may be as much as 60 feet wide if trusses are used.

The half-and full-arch are two other roof types. The roof framing is constructed of prefabricated or laminated beams. The half-arch is generally entered from the side, while the full-arch must be entered from the end.

The span on a half-arch roof is limited to about 25 feet.

An umbrella roof is used to store items and protects them from direct rainfall and snow.

The gambrel roof was more popular in the 1930s. It allowed more space for storage in the upper part of the structure and was used by many farms for the storage of hay.

Rigid steel frames are available with post free spans of 70 feet or more. These are tested by the manufacturer for stress and will stand wind pressure if constructed according to the manufacturer's specifications. The use of this type of roof support is increasing in popularity.

Regardless of the type used, the roof frames must be strong enough to withstand wind pressure, the weight of snow, and to support the roof. The size and spacing of rafters, trusses, and steel frames are determined by the amount of wind pressure expected, weight of roofing materials, length of rafters, and dimension of lumber used for the roof framing. The dimensions of the lumber have the greatest influence on the strength of the roof.

For example, a 2" x 8" is four times as strong as a 2" x 4" and twice as strong as a 4" x 4". The grade of lumber also affects its strength.

ROOF FRAMING

Transparency No. 2

Along with determining the type of roof to use, the builder must be familiar with the types of roof framing. Attention is called to the maximum recommended widths for each type of framing. Some manufactured frames are shown in the following transparency.

Transparency No. 3

CONSTRUCTION PRACTICES

The most critical areas in a structure affecting its strength are (1) where rafters or trusses join the plate, side walls, or columns; (2) where poles rest on piers; (3) where the sill rests on the foundation; and (4) where rafters are joined at the roof ridge. The practices or methods used in joining the different parts of a building are very important, as they affect its length of useful life.

FOUNDATIONS AND WALL SUPPORTS

Different kinds of foundations and the ways foundations are joined to other structural parts are shown in the following transparency.

Transparency No. 4

Poles are often used for the foundations of utility buildings; and they make good foundations if they are placed at the proper depth, are backfilled properly, and the roof is well-anchored to the poles. Eight inches of concrete or one foot of gravel should be placed in the bottoms of the holes to prevent the poles from sinking deeper into the soil.

The length of the poles to be used and the method used to set the poles will determine the depth of the holes. Usually the hole depth will vary from four to six feet. Holes in soft soils should be dug at the greater depth. A rule of thumb for hole depth is four feet for poles 16 feet or less in length and a hole depth of five to six feet for poles 16 to 25 feet long. Shallower holes may be used if the poles are encased in concrete. Metal poles having bearing plates resist overturning and uplifting much better than wooden poles, and may be set at a shallower depth.

A concrete footing is used for the foundation, it should be twice as wide as the pier or masonry blocks which rest upon it. The thickness of the footing should also be twice the thickness of the foundation wall. For example, the footing for a ten-inch thick foundation wall should be 20 inches thick. The above recommendations must be followed if the foundation is to resist settling due to the weight of the building; soil movement caused by moisture changes, freezing, and thawing; and the uplift and overturning force of wind.

ANCHORING ROOF FRAMING TO POLES AND WOOD FRAMES

Transparency No. 5

The method used to anchor the roof to the poles affects the strength of the building, and the method to use will depend upon the size of the building. An illustration of one method of fastening rafters to joists is shown. There are other equally as satisfactory methods.

The size of wood framing materials to use for walls depends upon the amount of weight the wall is expected to carry. A side load (wall storage area), or an overhead load, such as a hoist, will require the use of larger dimensioned studs or poles. The kind and amount of wall bracing used also affects the size of lumber to use.

SELECTING ROOFING MATERIALS

Cost, life expectancy, resistance to hail and fire, slope of roof, and resistance to wind and sun are factors to consider in selecting roofing materials.

Transparency No. 6

Sheets of asbestos - cement have a long life expectancy and are resistant to the elements of nature; however, they are easily damaged by a heavy impact, such as a rock. They are also heavier than most other kinds of roofing materials.

Galvanized steel and aluminum sheets are the most popular roofing materials for farm structures. They have a long life expectancy, are resistant to the elements of nature, and are fire proof. However, the builder is reminded that the gauge and coating of zinc affect life expectancy of galvanized steel. The minimum recommended gauge of galvanized steel is 29 with at least two ounces of zinc coating. The minimum aluminum gauge recommendation is .0215. Aluminum sheets must be well-secured (nailed or other means of fastening) to resist wind.

Wood shingles do not last as long as galvanized steel, aluminum, or abestos-cement shingles; and they readily burn.

Asphalt shingles are more expensive because they must be put over solid decking; and after becoming heated, they will burn. The life expectancy of asphalt shingles is shorter than steel, aluminum, and asbestos-cement shingles.

Both types of asphalt rolled roofing are similar in all aspects to asphalt shingles.

III. Figuring Material Costs

Since most builders must have a fairly accurate estimate of the cost of a structure before it is built, the cost of a structure is very important to its construction. The cost should be determined before the plans are completely finalized to allow for the substitution of materials and possible plan changes to reduce cost, if it is necessary.

The first step in estimating building cost is to review the blueprint and determine the areas of the structure that are similar in construction and require similar materials. Structures usually have parts that form a square, rectangle, or triangle. Areas that are similar are designated on the blueprint by numerals or letters. The bill of materials is figured for one area and is multiplied by the number of areas that are similar.

Building materials such as lumber, siding, and roofing are calculated by area. Height x length = area. A sample bill of materials is figured below.

Transparency No. 7

The example in the above transparency is of a rectangular building which has several areas requiring the same amount of materials. These are designated in the illustrations as A, D, E, and F. The materials required for one area are determined and multiplied by two to determine the amount and cost of materials for both areas. Side C in the example is open. It is assumed that 2" x 6" lumber will be used for studs, rafters, and braces and galvanized sheet iron or aluminum will be used for siding and roofing. Studs are placed two feet apart, and two studs are used at each corner.

BILL OF MATERIALS FOR ONE "A" WALL

18 pieces of 2" x 6" x 12' are needed for one "A" wall. Both "A" walls will require 36 pieces for studs.

5 pieces of 2" x 6" x 12' are required for the sill for one "A" wall. 9 pieces will be required for both "A" walls. (One "A" wall only requires about 2 feet of one of the 2" x 6s" used for the sill.).

If the 2" x 6s" are doubled at the plate, 9 pieces of 2" x 6s" are required for the plate in one "A" wall. Both "A" walls will require 18 pieces. (There will be some waste in this area.)

The siding required for the "A" walls is determined as follows:
One "A" wall dimension - 12' x 30' = 360 sq. ft.
x 2
Area in both "A" walls - 720 sq. ft.

Sheet iron or aluminum, as previously stated, will be used for siding. Siding is sold by the square. A square is 100 sq. feet, or a 10 ft. by 10 ft. area. The most commonly used sheets are 26 inches wide; however, wider sheets are available. The 26-inch sheet allows a two-inch lap or joint where sheets are joined. Therefore, a 26-inch sheet actually covers 24 inches of wall space. A 26" x 12' sheet of galvanized sheet iron would cover 26 square feet of space if it was not lapped; but because of the lap, the sheet only covers 24 square feet of siding space. To cover 360 square feet of wall space, 3.9 squares or 15 sheets of 26" x 12' galvanized iron are required. Twice as much is required to cover both of the "A" walls.

The materials used in the other areas of a structure are calculated in the same manner.

A fairly accurate estimate can be made of the cost of a structure by determining the number of square feet in the building and multiplying this by the cost per square foot for similar structure. After a builder has had some experience in building and figuring bills of materials, he can make a rather accurate cost estimate. This is a popular method for experienced builders. Open and/or unfinished areas, such as sheds, are calculated on a different basis than completely enclosed areas.

Another method used to calculate building cost is to use cubic feet. This method is used to determine the volume of buildings beyond the average one-story height. Volume is determined by multiplying the length x width x height. Dimensions used are six inches below the floor to the top of the roof for building with flat roofs. On a pitch roof, the top measurement is taken at a point one-half the gable height (b+1/2a.). The cost of the structure is divided by the total volume to find the cost per cubic foot.

IV. Laying Out Rafters and Trusses

Prior to beginning the study on rafters, the student should become familiar with the parts of the square and the tables on the square. The tables are discussed in detail in the student materials, "Measuring and Marking Devices," and provide the information needed to determine the length and cuts of rafters.

The student should also know the terms used for the different parts of rafters and building parts joined to rafters and trusses.

Transparency No. 8

Plumb cut - This is vertical cut at the top end of a rafter, at the seat cut, and may be the cut at the tail end. The plumb cut at the ridge is referred to as the top plumb cut, while the plumb cut at the tail is referred to as the bottom plumb cut.

Seat cut or bird's mouth - The seat cut rests on the plate. The square is used to make the correct angle and depth of cut. The depth of cut should usually be no more than one-half the width of the lumber used for the rafters.

Plate - The top part of the wall on which the seat cut rests.

Ridge - This is the top of the roof or highest framing member where two rafters are joined. A ridge board is sometimes used between the rafters to strengthen the framing members. A ridge board also aids in aligning the roof and tying the roof members together.

Span - This is the distance from one outer plate edge to the outer plate edge of the opposite wall. It is the width of the building.

Run - The distance from the edge of one outer plate to the center of the building.

Rise - The vertical distance from the top of the plate to the ridge. Several methods may be used to find the rise of a building: (1) Multiply pitch x span; (2) Rise per foot of run is determined by multiplying pitch by 24; and (3) Divide rise by span and multiply by 24.

Pitch - The slope of the roof, or the number of inches of rise per foot of run. Pitch is usually expressed as a fraction, such as 1/3, 1/4, 1/6, etc.

Transparency No. 9

Rafters are laid out (stepped-off) with a carpenter square. The square forms a right angle and is composed of two parts, the blade (24 inches long) and the tongue (16 inches long). The numerals on the tongue of the square are used to designate the rise, while the blade is used to designate the run. The pitch and the kind of rafters being cut determine the numerals used on the tongue and blade of the squre.

NUMERALS USED FOR DIFFERENT PITCHES
Common Rafters

Pitch	Run	Rise
1/12	12"	2"
1/8	12"	3"
1/6	12"	4"
1/4	12"	6"
1/3	12"	8"
1/2	12"	12"
3/4	12"	18"

The "stepping method" is the easiest method for measuring and marking rafters. After the pitch has been decided, the numerals to use on the tongue and blade are located. The square is then set on the edge in the rafter stock as shown in Step No. 1 in the above transparency. The plumb line is marked in the first step. A line is drawn at each outside edge and at the numerals used on the tongue and blade of the square. For the second foot of run, the square is moved to Step No. 2. (The numeral on the tongue is placed on the mark made by the numeral used on the blade in the preceding step.). For the third foot of run, the square is moved to the third position, etc. The square is moved as many times as there are total feet of run. Framing square clips which may be fastened to the square to maintain the correct measurements are available. After the required number of steps have been taken, the seat cut is marked. This is accomplished by measuring the distance on the plumb line or depth of the seat cut and moving the square to the right on the board until the square is "lined up" with the depth mark. A level line is drawn along the square at this point.

Next, the length of overhang or tail is determined. It may be most any length. The length is measured from the plumb cut at the seat and on the top edge of the rafter. Several different cuts can be made at the end of the overhang, but usually a plumb cut is made.

If a ridge board is used, one-half of the width of the ridge board must be removed from the top end of the rafter. After the measurement is taken, a line is drawn perpendicular to the plumb line.

Rafters for a shed roof are cut in the same manner; however, two seat cuts are made; and the run is the width of the building.

To determine the length and proper seat cuts for a shed roof that does not have a standard pitch, the builder only needs to determine the number of inches of rise per foot of span. The number of inches of rise per foot of span and fractional inches are used on the tongue of the square, and 12 is used on the blade. A step on the square is taken for each foot of span. For example, for an eight foot wide building with one wall 30 inches higher than the other wall, the numerals to use on the tongue would be 3.75 inches (30" ÷ 8' = 3.75 inches, or 3.75 inches per foot of run).

Valley and hip rafters are "stepped off" in the same manner as common rafters, except 17 is used on the blade instead of 12.

Jack rafters are the same length per foot of run as common rafters with the same pitch. The lower plumb cut of a hip jack and upper plumb cut of a valley jack are the same as these cuts on a common rafter. Some difficulty may be experienced in determining the length and side cut on the hip jack and valley jack and in getting the proper fit against the hip and valley rafters. The sidecuts, however, for these may be found on a good framing square.

Generally the first rafter cut for common and shed rafters are used as a pattern for marking the other rafters of the same kind and length.

Prior to cutting a rafter and before ordering the lumber for rafters, the builder will need to determine the length of rafter stock to order. Several methods may be used to determine the length of the stock needed. The simplest method is to measure the distance between 12 on the blade (run) of the square and the rise per foot of run on the tongue. This distance is multiplied by the number of feet of run in the building, and the overhang measurement is added to this. For example, there are 14.42 inches per foot of run when an 1/3 pitch is used. For a building with 10 feet of run and 16 inches of overhang on the rafter, the rafter stock should be 16 feet long (10 x 14.42 = 14420 inches ÷ 12 = 14.42 feet + 16 inches overhang = 15.82 feet. The rafter stock should be 16 feet long.). The rafter and framing table on the square also will provide the builder with the length of rafter per foot of run. Charts providing the same information are also available.

ROOF TRUSSES

A truss is a structural framework made of lumber or metal and is composed of a number of members fastened together. They are constructed so that the external load will cause only direct stress on the members.

Trusses allow the builder to cover a large area with a clear or post free span and are particularly adapted to pole buildings. Properly constructed trusses can be spaced at great intervals, and the lumber used in building trusses does not have to be cut to an exact fit. Some disadvantages are a jig must be constructed; trusses must be built on the ground; and special equipment may be required to raise them in place. Also, unless a number of trusses are to be built, their construction may require more labor. Trusses must be constructed to specifications; otherwise, they will not have the strength desired.

Transparency No. 10

The size of each part of a truss and the method used to join the members depend upon the span, slope (pitch), and load. The top chord serves as the rafters, and sheathing and other roofing parts are fastened to it. If the building will have a ceiling, it is fastened or hung from the bottom chord. The parts may be fastened by several means. Wood or metal gussets and bolts and split rings are two methods.

V. Framing a Building

The framing method used depends upon the type of building and the materials to be used in the structure. In pole buildings, the framing is attached to the poles, and the siding is attached to the frame. The size of framing materials will depend upon the strength desired, type of siding to be used, and cost.

Transparency No. 11

The three most common kinds of frames are poles, platform, and balloon. Each floor is framed separately in platform framing. For example, in the construction of a two-story building, the first floor is framed, room partitions are placed, and the sub-floor for the second story is placed on top of the first floor frames and partitions. If balloon framing is used, the studs are long enough to frame the exterior walls for both floors. The joists for the second floor rest on ribbon boards and the top of the first floor partition walls.

Transparency No. 12

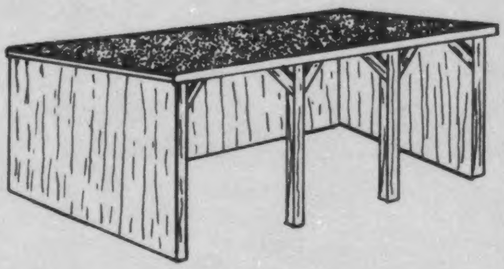
The sills rest on and are joined at the foundation (poles, concrete slab, etc.) and are single or doubled 2 x 4, 2 x 6, or 2 x 8. If the foundation is concrete, an anchor (bolt or other type of anchor) is used to join the foundation and sill. The anchor is embedded in the concrete when it is placed. Anchors prevent the building from shifting under high wind pressure. Three kinds of sill construction are shown in the above illustration.

References:

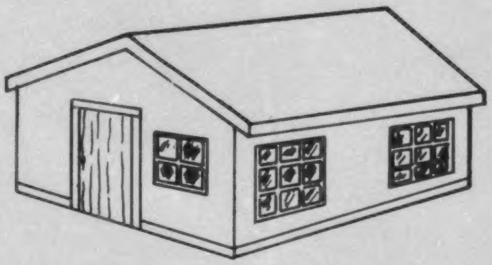
1. "Utility Buildings", American Association for Vocational Instructional Materials, University of Georgia, Athens, Georgia, 1974

2. Durbahn, Walter E. and Elmer W. Sundberg, *Fundamentals of Carpentry*, Vol. 2, American Technical Society, Chicago, Illinois, 1972

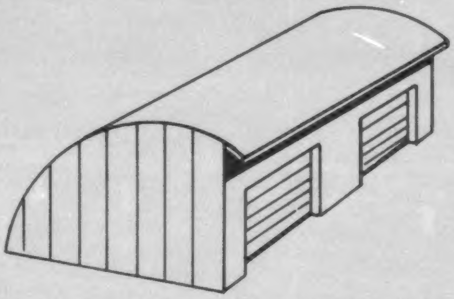
ROOF TYPES



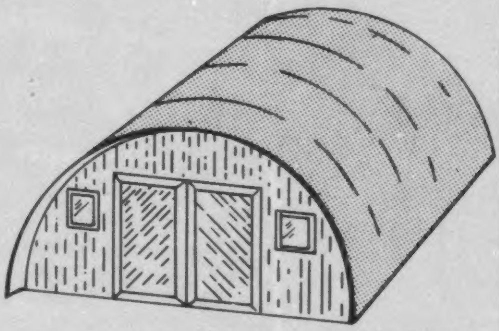
SHED ROOF



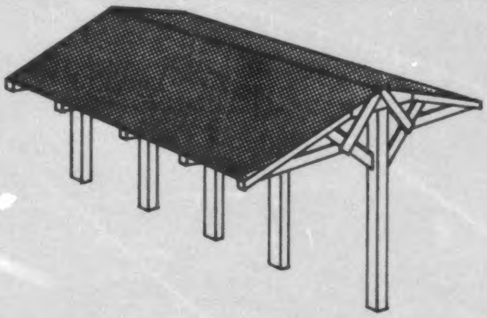
GABLE ROOF



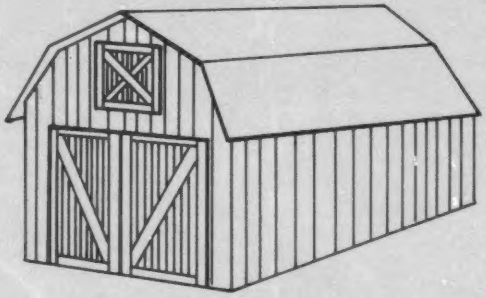
HALF-ARCH ROOF



FULL-ARCH ROOF

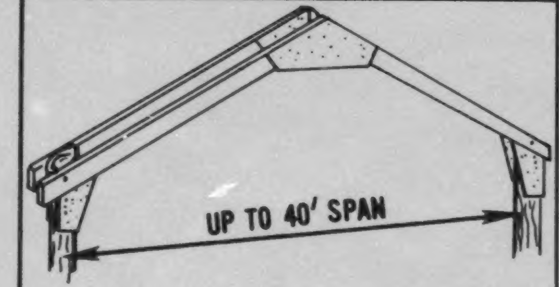


UMBRELLA ROOF

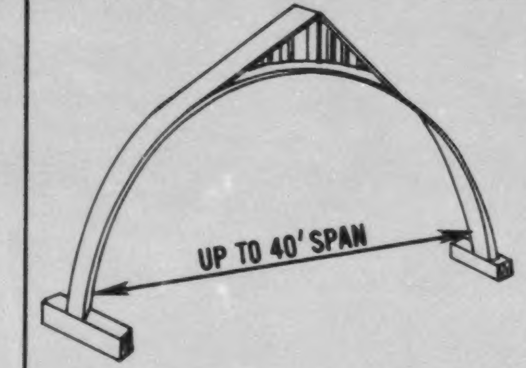


GAMBLE ROOF

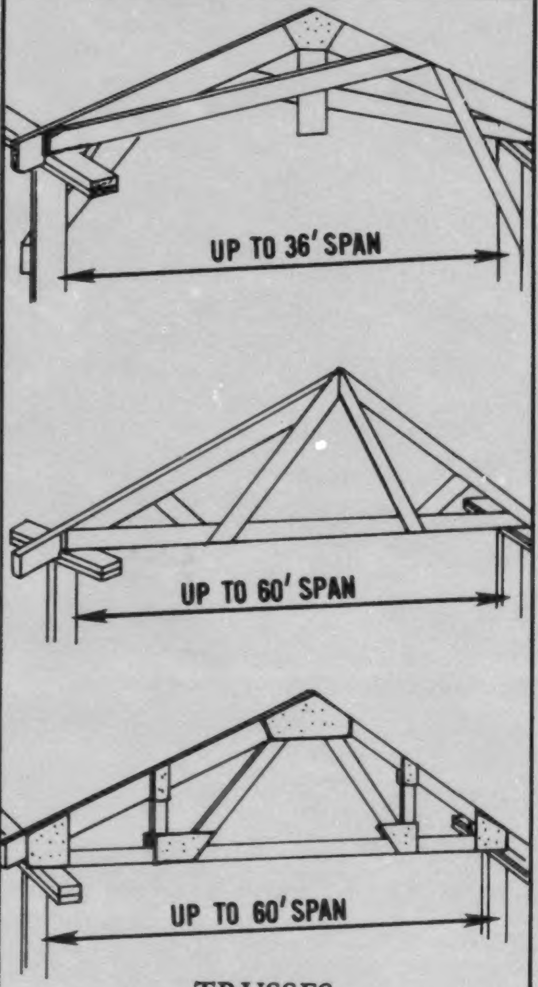
TYPES OF ROOF FRAMING


UP TO 40' SPAN

RIGID-WOOD FRAME

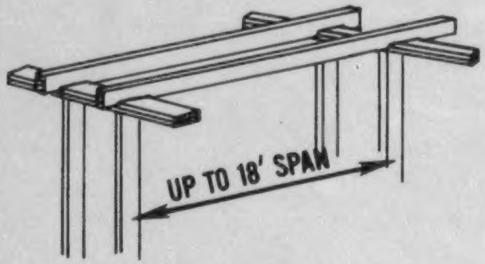

UP TO 40' SPAN

CURVED-ARCH RAFTERS

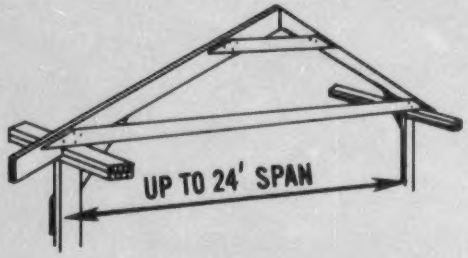

UP TO 36' SPAN
UP TO 60' SPAN
UP TO 60' SPAN

TRUSSES

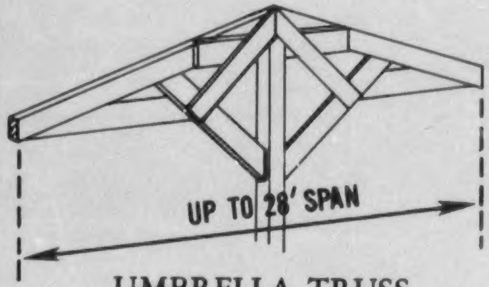
WIDE SPANS


UP TO 18' SPAN

SHED ROOF RAFTERS


UP TO 24' SPAN

GABLE ROOF RAFTERS

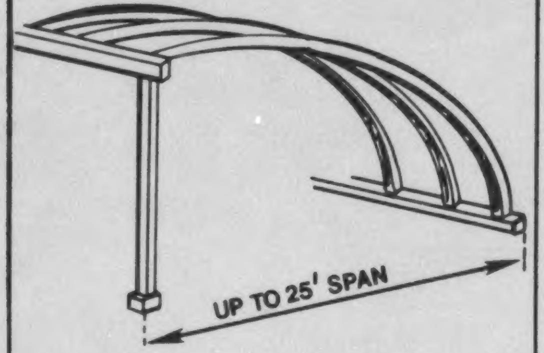

UP TO 28' SPAN

UMBRELLA TRUSS

NARROW SPANS

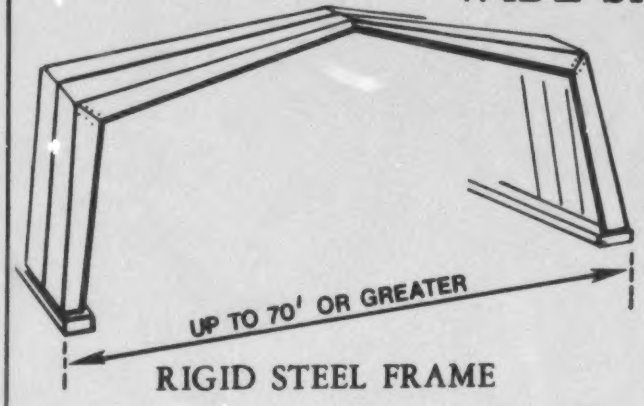
MANUFACTURED FRAMING MATERIALS

NARROW SPAN

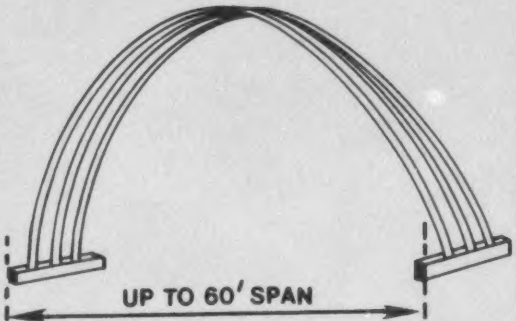

UP TO 25' SPAN

HALF-ARCH FRAME

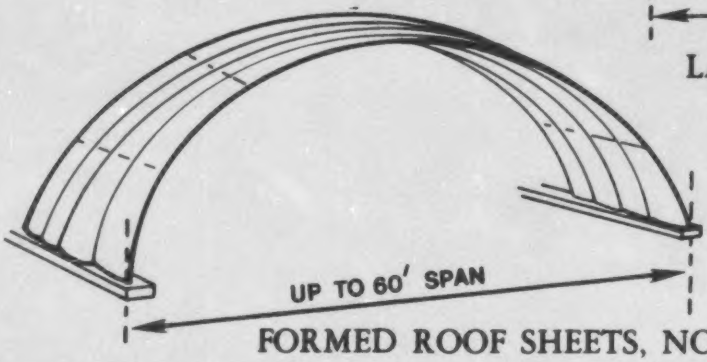
WIDE SPANS


UP TO 70' OR GREATER

RIGID STEEL FRAME

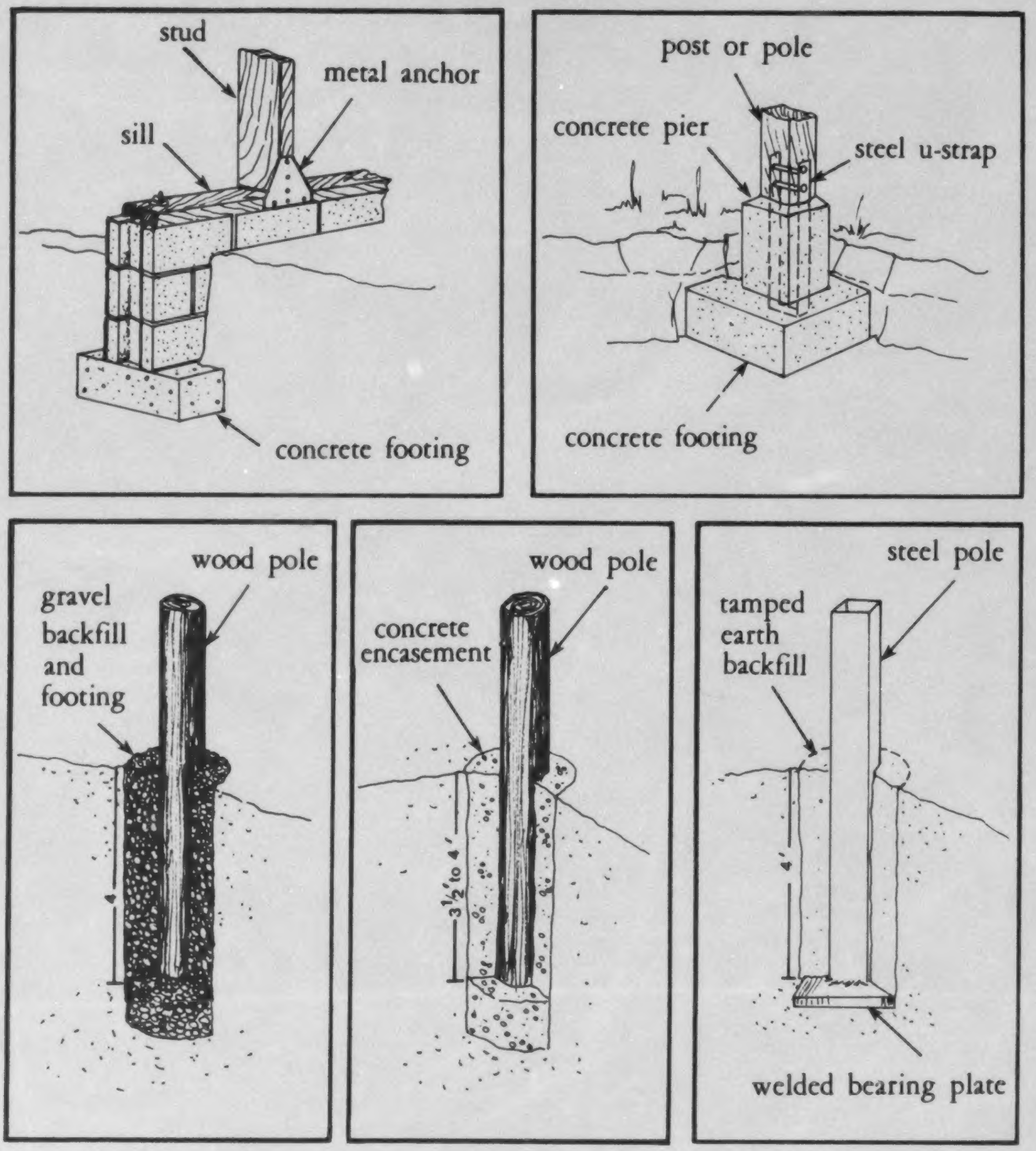

UP TO 60' SPAN

LAMINATED or STEEL FRAME RAFTERS

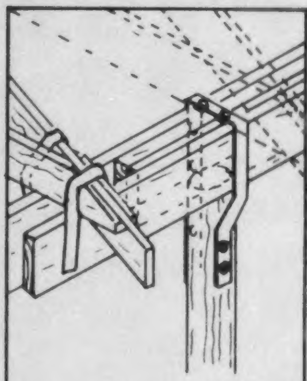

UP TO 60' SPAN

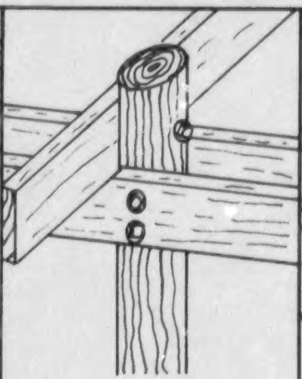
FORMED ROOF SHEETS, NO FRAME

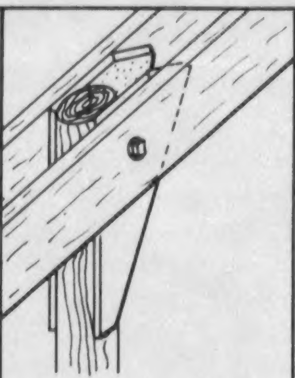
FOUNDATIONS AND WALL SUPPORTS

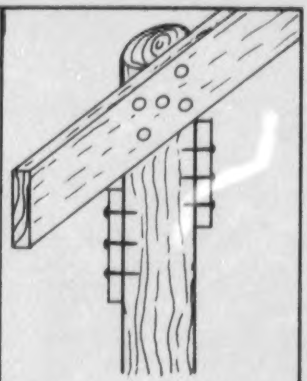

stud
metal anchor
sill
concrete footing
post or pole
concrete pier
steel u-strap
concrete footing
wood pole
gravel backfill and footing
4'
wood pole
concrete encasement
3½' to 4'
steel pole
tamped earth backfill
4'
welded bearing plate

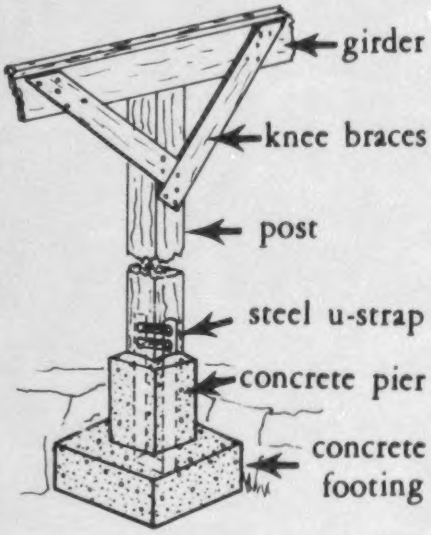
ANCHORING ROOF FRAMINGS


Steel straps attaching lintel & truss to girder

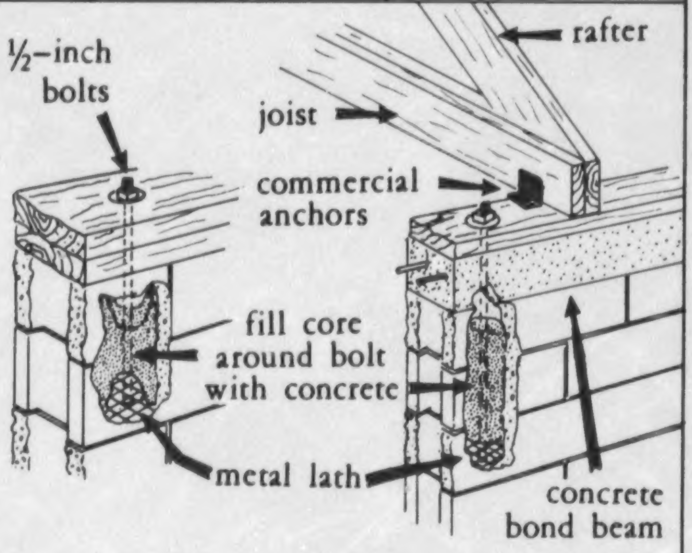

Bolts attaching girder & roof framing


Gusset plates & bolts attaching rafters to pole


Nails attaching purlins & rafters

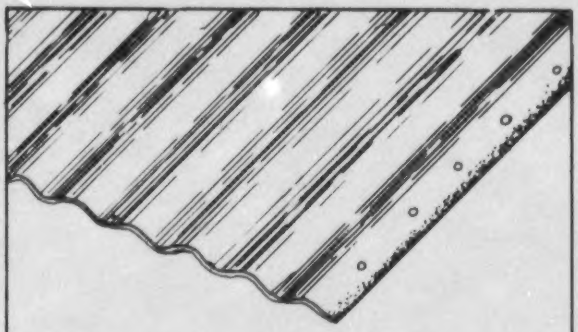

girder
knee braces
post
steel u-strap
concrete pier
concrete footing

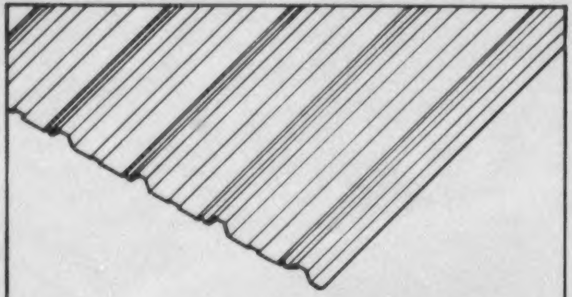
POST & PIER BRACING

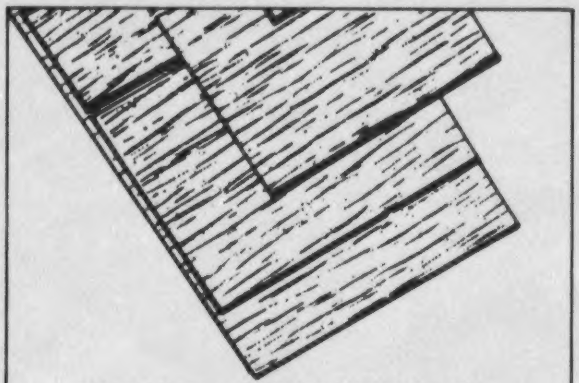

½-inch bolts
rafter
joist
commercial anchors
fill core around bolt with concrete
metal lath
concrete bond beam

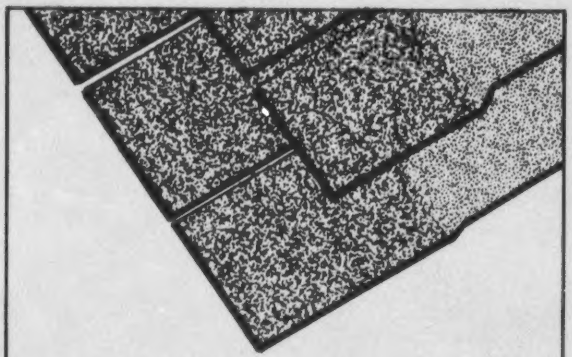
ATTACHING ROOF FRAMING TO MASONRY WALL

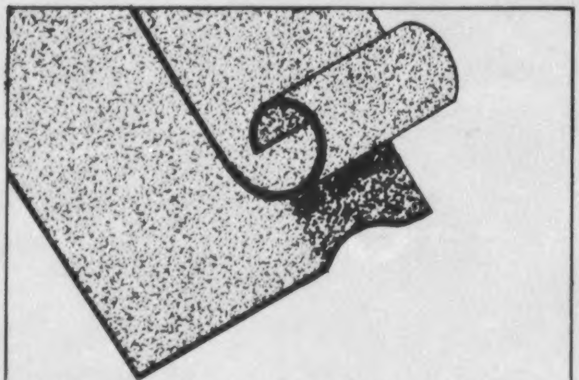
ROOFING MATERIALS

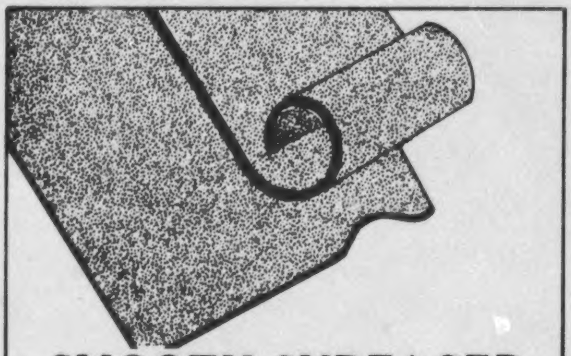

ASBESTOS-CEMENT


STEEL OR ALUMINUM

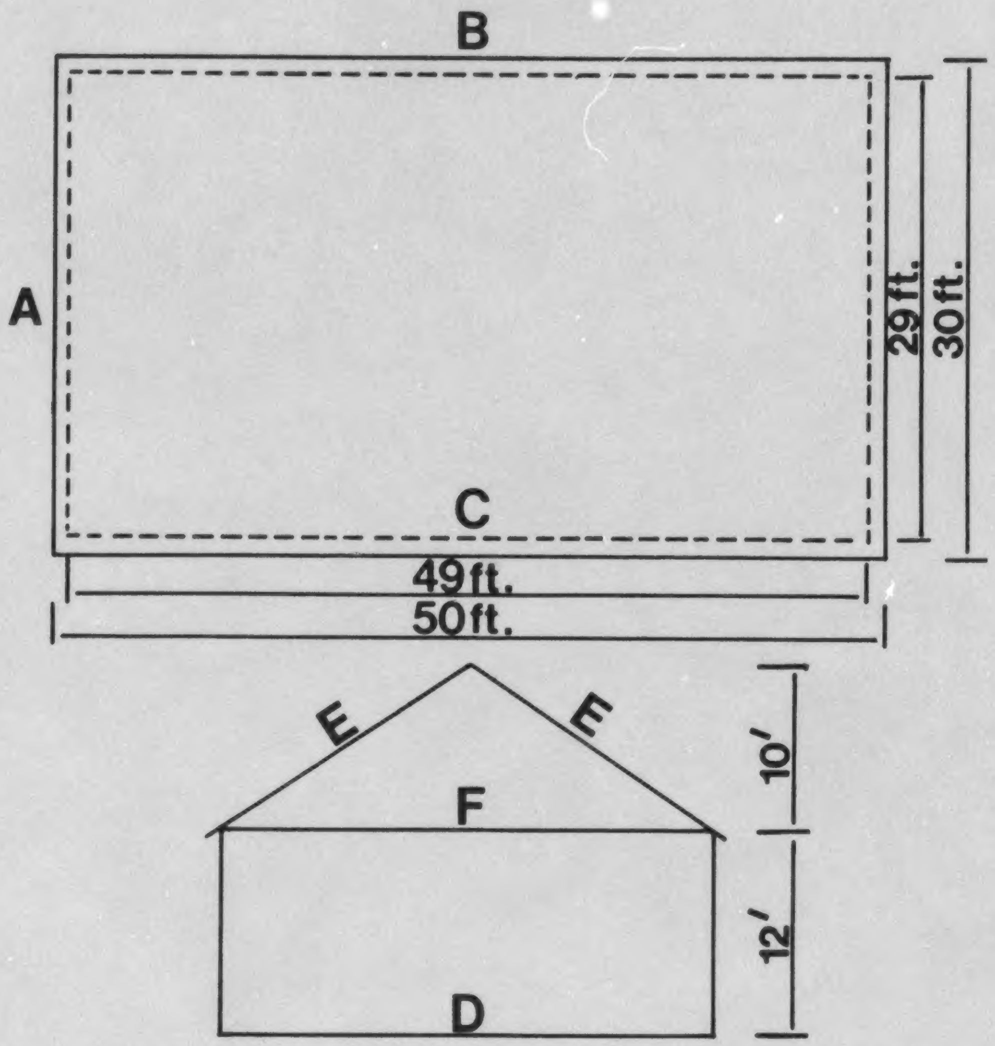

WOOD SHINGLES


ASPHALT SHINGLES


SELVAGE-EDGE ROLL

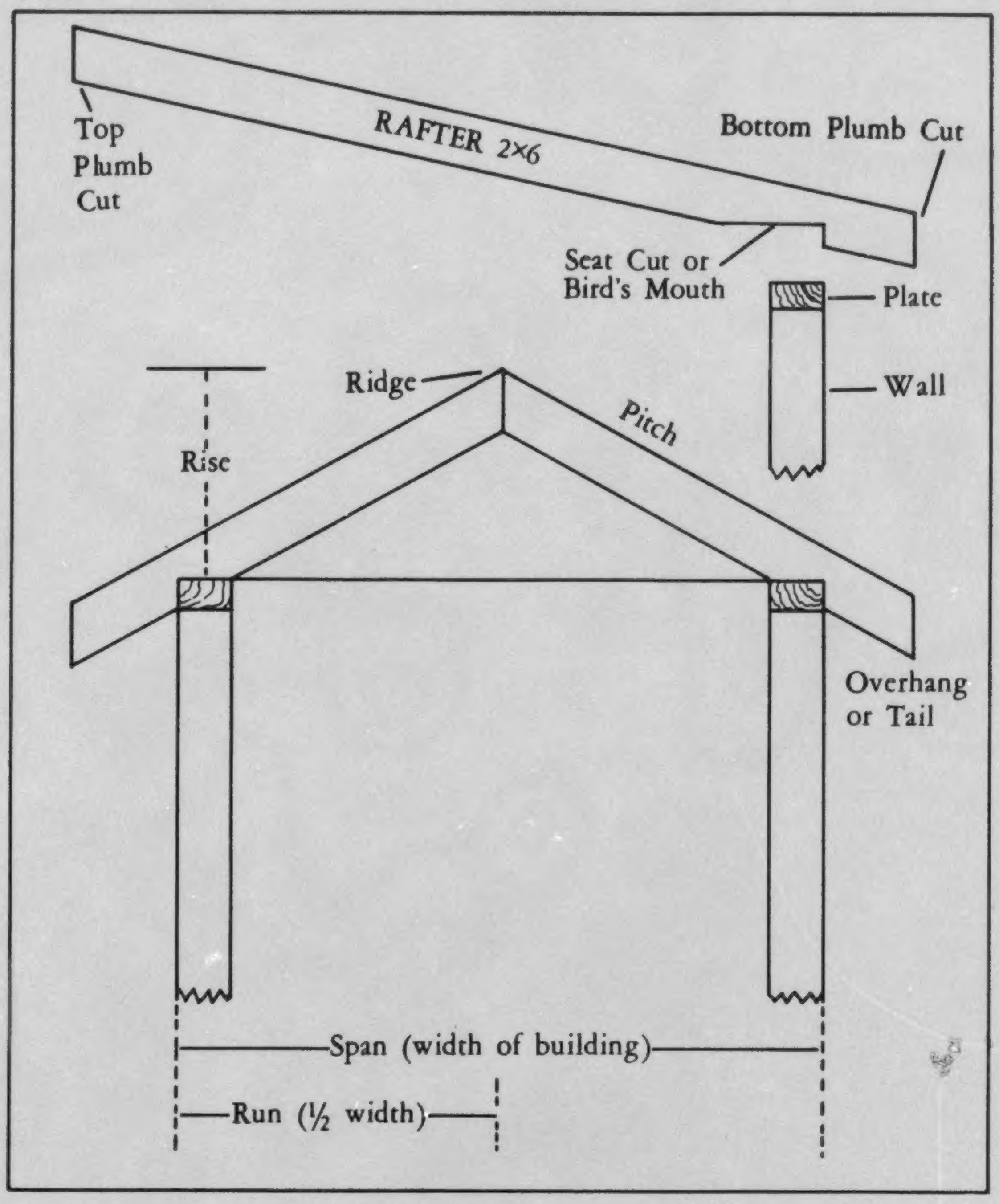

SMOOTH-SURFACED ROLL

CALCULATING BUILDING MATERIALS BY AREAS

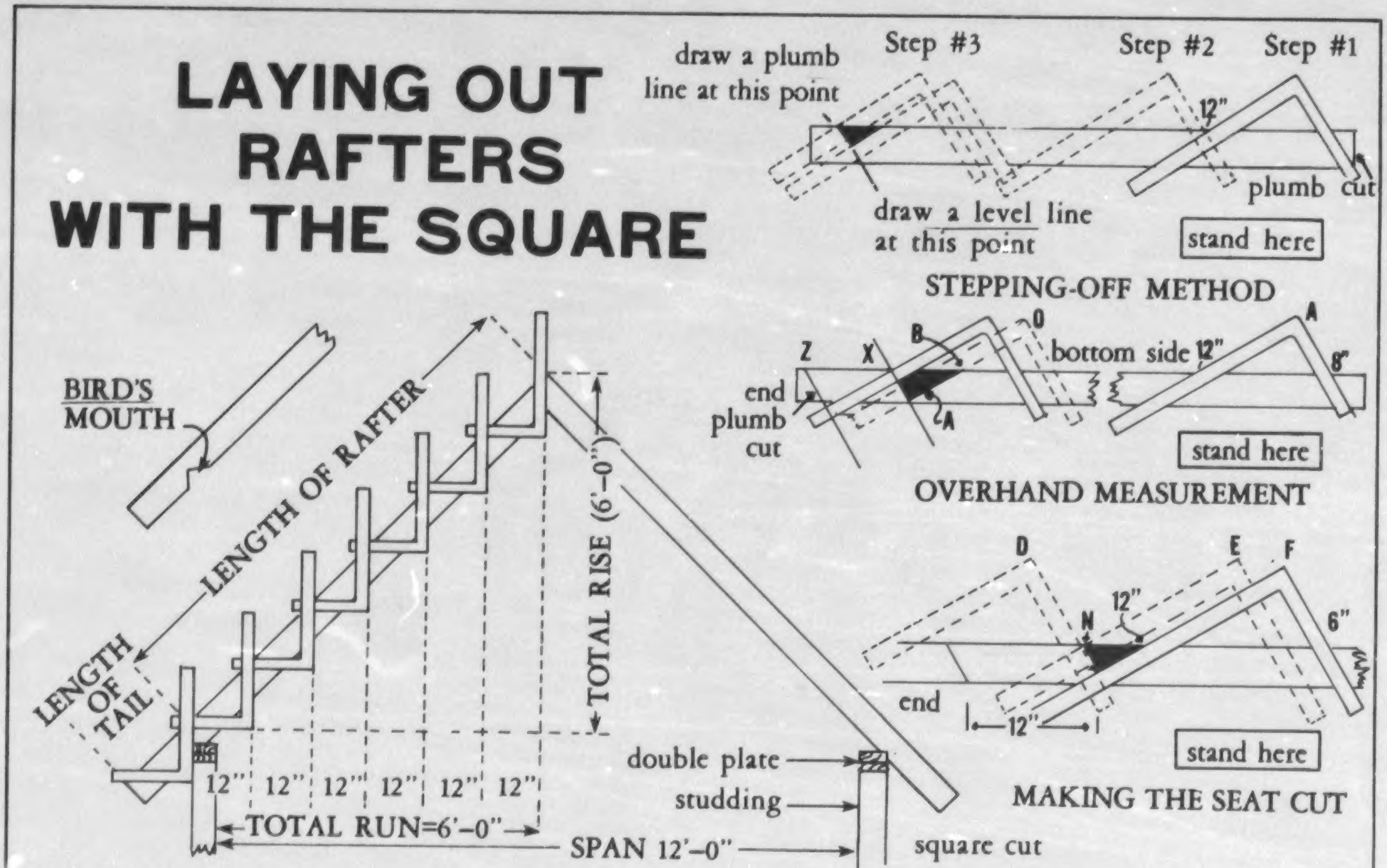

B
A
C
29 ft.
30 ft.
49 ft.
50 ft.
E
E
F
10′
12′
D

Scale: 1 inch = 10 feet

RAFTER CUTTING TERMS


Top
Plumb
Cut
RAFTER 2×6
Bottom Plumb Cut
Seat Cut or
Bird's Mouth
Plate
Wall
Ridge
Pitch
Rise
Overhang
or Tail
Span (width of building)
Run (½ width)

LAYING OUT RAFTERS WITH THE SQUARE


draw a plumb line at this point
Step #3
Step #2
Step #1
12"
plumb cut
draw a level line at this point
stand here
Z
X
B
O
bottom side
12"
A
8"
end plumb cut
A
stand here
D
E
F
12"
N
6"
end
12"
stand here
BIRD'S MOUTH
LENGTH OF RAFTER
LENGTH OF TAIL
TOTAL RISE (6'–0")
12" 12" 12" 12" 12" 12"
TOTAL RUN=6'–0"
SPAN 12'–0"
double plate
studding
square cut

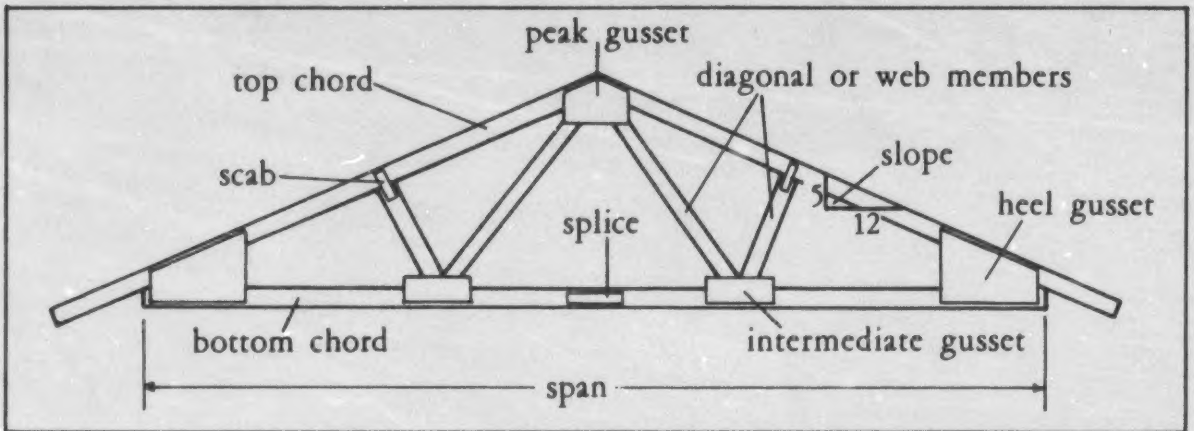
STEPPING-OFF METHOD

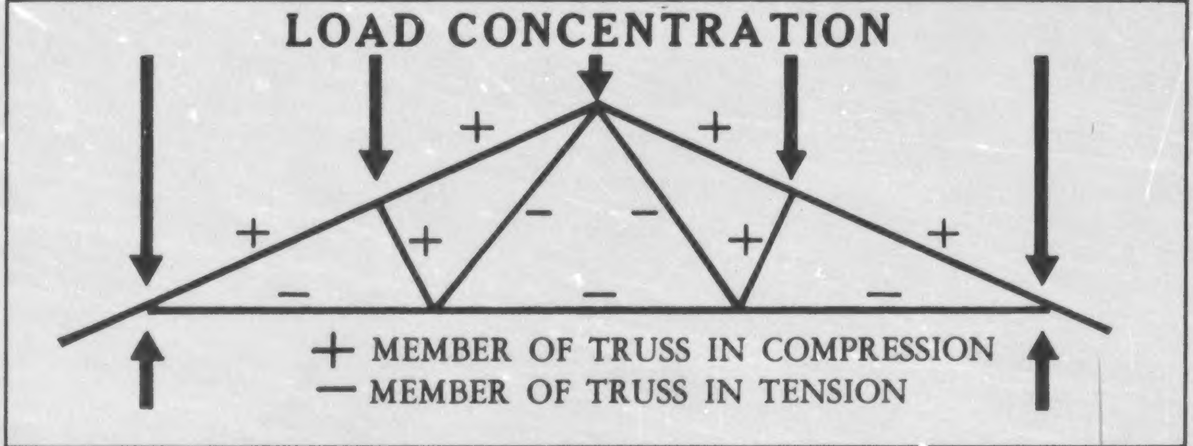
OVERHAND MEASUREMENT

MAKING THE SEAT CUT

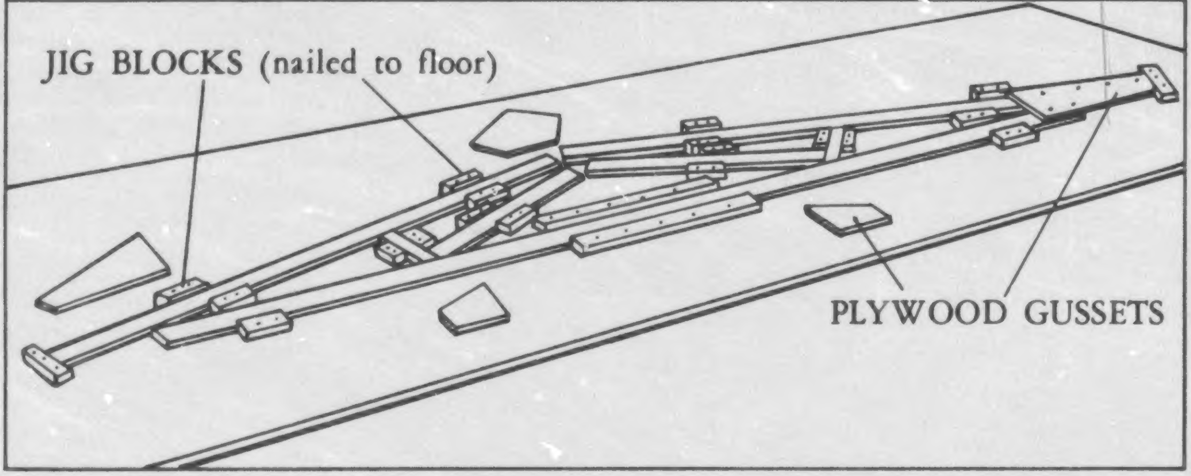
PITCH=RISE DIVIDED BY THE SPAN.

TRUSS PARTS & LOAD

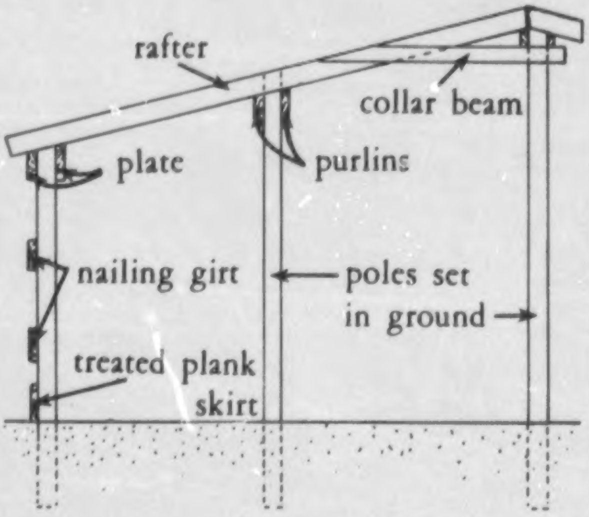

peak gusset
top chord
diagonal or web members
slope
scab
5
12
heel gusset
splice
bottom chord
intermediate gusset
span


LOAD CONCENTRATION

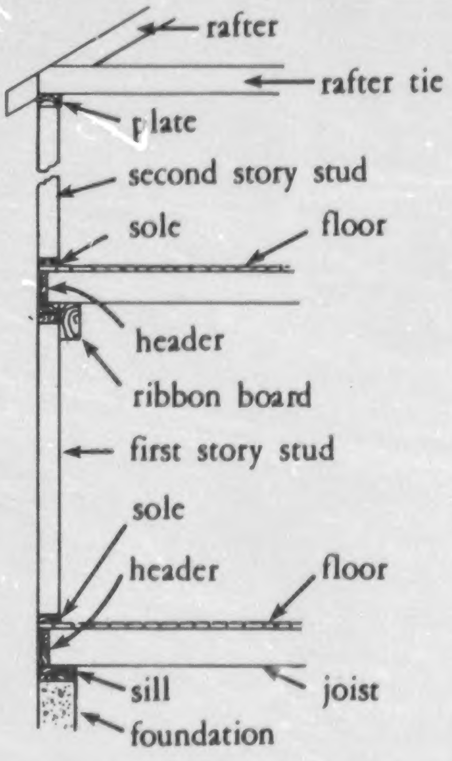
+ MEMBER OF TRUSS IN COMPRESSION
— MEMBER OF TRUSS IN TENSION


JIG BLOCKS (nailed to floor)
PLYWOOD GUSSETS

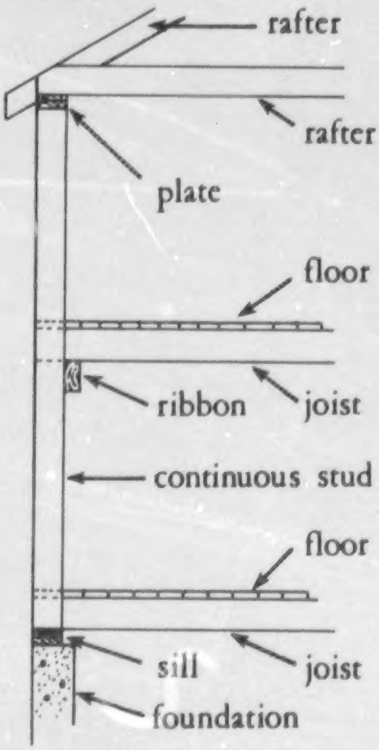
TYPES OF WOOD-FRAME STRUCTURES


rafter
collar beam
plate
purlins
nailing girt
poles set in ground
treated plank skirt

POLE FRAME

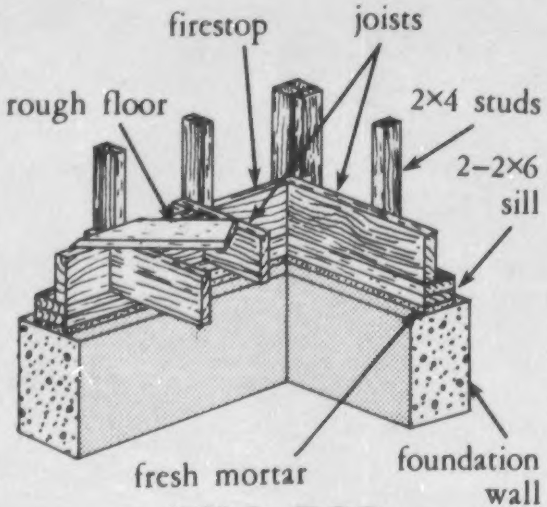

rafter
rafter tie
plate
second story stud
sole
floor
header
ribbon board
first story stud
sole
header
floor
sill
joist
foundation

PLATFORM FRAME
each floor is framed separately

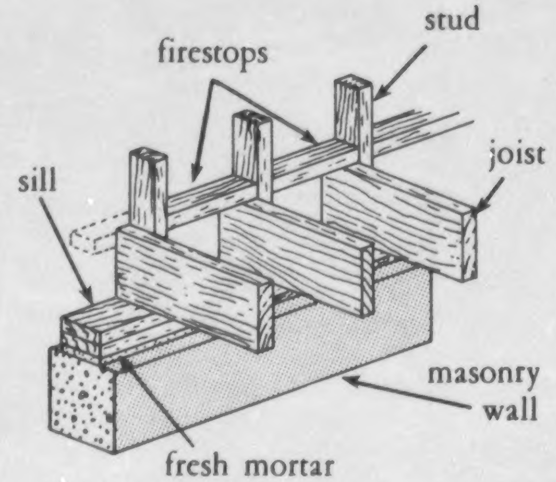

rafter
rafter tie
plate
floor
ribbon
joist
continuous stud
floor
sill
joist
foundation

BALLOON FRAME
studs extend the height of both stories

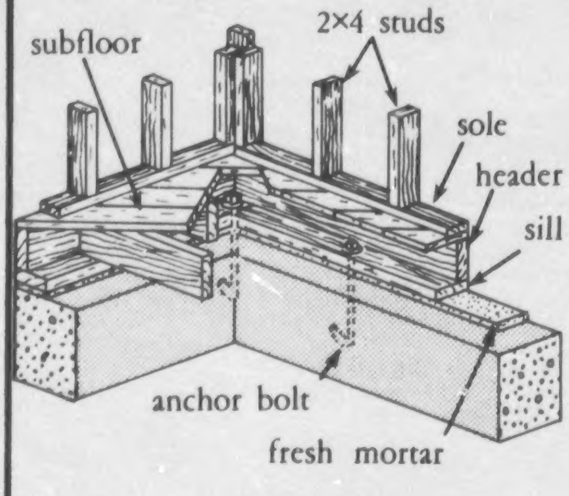
KINDS OF SILLS


firestop
joists
rough floor
2×4 studs
2–2×6
sill
fresh mortar
foundation
wall

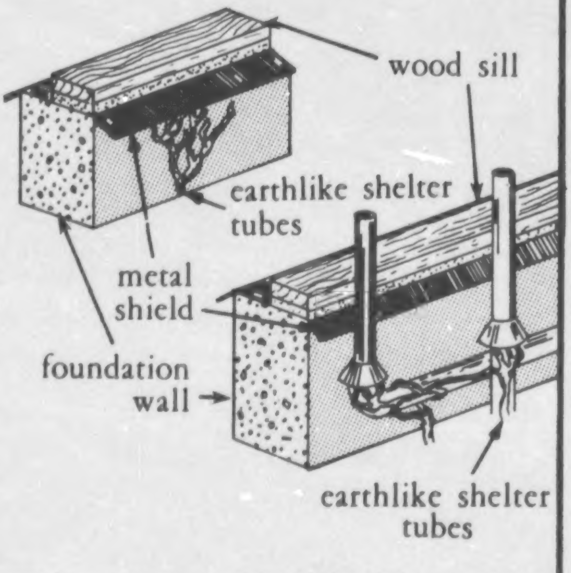
SILL FOR BALLOON FRAMING


stud
firestops
joist
sill
masonry
wall
fresh mortar

ALTERNATE SILL FOR BALLOON FRAMING


subfloor
2×4 studs
sole
header
sill
anchor bolt
fresh mortar

BOX SILL


wood sill
earthlike shelter
tubes
metal
shield
foundation
wall
earthlike shelter
tubes

TERMITE PROTECTION

GENERAL AGRICULTURAL MECHANICS

Unit Q: Farm Structures

Topic 2: Planning and Building Fences

1. Introduction

Properly constructed, well-maintained fences are indispensable to a farm with crops and livestock, for they provide protection for crops and livestock. It would be impossible to establish many of the good management practices without good fencing.

In very early times exact property boundaries were of little importance, because there was an abundance of land and a small number of people. As the population increased, land became scarce; and the exact location of property boundaries became important. The first fences were constructed for the purpose of establishing property boundaries.

Stones were probably the first materials used for the construction of fences for agricultural purposes. Other fencing materials used about the same time were wood (split timbers), mud, and growing plants. Hedge rows are still used as fences in some European countries.

The first wire used as fencing material was smooth, made from flat iron, and coated with zinc. Its popularity was almost instant because it was relatively inexpensive, easy to use, and provided the needed protection for property, crops, and livestock. Barbs were added to the smooth wire to prevent livestock from scratching on it, to prevent it from becoming loose, and to prevent the animals from pushing through it.

Over 400 different designs of barb wire were produced by different inventors. Lucien B. Smith of Kent, Ohio, received the first patent on June 25, 1867. Many other patents followed.

The first woven wire was produced in 1883 by a Civil War veteran, who recognized the need for such a wire while burning split-rails to keep warm.

2. Kinds of Fences and Their Uses

The three categories into which fences may be grouped are permanent, temporary, and growing. The kind of fence to construct will depend upon the area to be enclosed, purpose of fence, animals to be confined, and climatic conditions.

Materials that may be used for constructing permanent fences are boards, woven wire, barb wire, or a combination of these. Permanent fences are constructed to enclose an area for an indefinite period of time.

Temporary fences are used to confine animals in an area for a short period of time, or to serve as temporary protection for plants, buildings, and equipment. They may be constructed of barb or woven wire, wooden panels, and electric wire.

Growing fences are formed by growing plants, such as hedges and some rose species. Growing fences may serve as a windbreak as well as a fence; however, they are not effective in the confinement of all types of livestock.

3. Tools Used in Constructing Fences

Certain tools must be available for the builder to properly construct a fence. Different tools are required to construct the various kinds of fences. Some of the larger tools needed are shown in the following transparency, and others are listed below:

Transparency No. 1

1. Stakes
2. Six-foot rule
3. Heavy cord
4. Tamping bar
5. Crowbar
6. Post driver
7. Chain and hand saws
8. Brace and assorted bits
9. Hammer
10. Axe
11. Wire splicer
12. Shovel
13. Leather gloves
14. Plumb bob
15. 16-foot pole
16. Chain saw

4. Fencing Materials

Transparency No. 2

Post - The three most commonly used posts for fences are wood, steel, and concrete. However, a fiberglass post is being marketed and is reported to have a long life expectancy. More wooden posts are used in the Southwest than any other kind, but the use of steel posts has increased in the last few years. Some ranchers are using both wooden and steel posts in fences.

The durability of wooden posts varies depending upon climatic conditions, amount of heartwood, kind of wood used, whether the posts are treated or untreated, and the method of chemical treatment used. The most popular wooden posts in Texas are ashe juniper (cedar) and treated pine. Some farmers, however, still use split post oak posts.

Untreated cedar posts have a life expectancy of 15 to 25 years, and pressure treated pine posts have about the same length of life expectancy. Untreated pine posts are not recommended because of their short life expectancy, three to five years.

Two methods of treating pine posts are soaking and pressure treating. Posts soaked in a preservative will last from 15 to 20 years. Pressure treated posts have a longer life expectancy. Creosote, pentachlorophenol, and copper naphthenate are the preservatives most often used.

The three kinds of metal posts manufactured are the "A" bar, studded "Y", and the studded "T".

The studded "Y" and "T" posts are made of thicker metal; therefore, they have a longer life expectancy. One advantage of using metal posts is that they serve as a ground for the fence, thus provide protection from lightning. They are also fireproof.

Concrete posts are durable, but they are very heavy and are subject to breaking and weathering.

The type of soil, location of posts (wet soils, hillsides, and on the contour), and climatic conditions influence the size of wooden posts to use in the fence. General recommendations of diameter and length of wooden posts are as follows:

Kind of Posts	Diameter	Length
Line	3-5"	6½-7 ft.
Corner and brace	4-6"	6½-7 ft.
Gate	6" or more	7½-8 ft.

Wire - Woven, barbed, and smooth are the three kinds of wire used for fencing. These are manufactured in the United States, as well as in several foreign countries. Wire manufactured in the U.S. is referred to as domestic wire, while wire manufactured in other countries is designated as imported.

A number of factors affect the life expectancy of wire. The most important is the amount of kind of protective coating on the wire. Rusting reduces the strength of the wire by reducing the wire size. Zinc (galvanized wire) and aluminum are the two coatings normally used. These coatings serve as a protective covering and delay the rusting of the wire. Zinc coating on wire is measured in ounces per square foot of wire surface. The more zinc per square foot, the longer the wire will last before it starts rusting. The amount of zinc coating is designated by classes, which were established by the American Society for Testing. Wire with a Class I coating has the least amount of coating, while Class III has the greatest amount. Class III wire takes about twice as long as Class I before beginning to rust. During the handling of wire, care should be taken not to damage the zinc coating. Damaged wire rusts much faster. Aluminum coated wire has three to five times the corrosion resistance as does zinc coated wire, but is is much more expensive.

The hardness of steel used in the manufacture of wire affects its life expectancy. A medium-hard steel provides a springing action which is important to a long life expectancy.

Atmospheric temperature also affects wire. Wire expands during warm weather and contracts during cold weather. If the wire is stretched too tight in warm weather, it is a possibility that it will break in cold weather.

Transparency No. 3

Wire size is designated by its gauge. The smaller the gauge, the larger the diameter of the wire. Smaller gauge wires have less zinc coating; therefore, they start rusting much sooner.

Woven wire is used to confine small animals such as sheep, goats, and swine. It also is used to confine a combination of small animals and large animals. Woven wire is available in several different designs or styles. The words design and style are used interchangeably by the manufacturer. Wire designs are identified by numerals, such as 1155, 1047, 939, etc. The first two numerals in the design number denote the number of line wires (wires running lengthwise), and the last two numerals indicate the height of the wire in inches. For example, design 1155 has 11 line wires and is 55 inches high.

Wires vertical to the line wires are called stay wires. Some manufacturers include additional numerals along with the design numbers. The numerals may appear as 1155-12-11. As stated above, the first four digits are the style numbers. The next two digits, 12, are the number of inches of space between the stay wires; and the digits 11 designate the size of filler wire, the wires between the top and bottom line wires.

Woven wire has tension curves in the line wires to provide a springing action. Attention is directed to the above transparency, which shows the tension curves in woven wire that is properly stretched. The place where woven wire is joined is called a joint. Hinge and stiff-stay are the two kinds of joints used in the manufacture of wire. The hinge joint is the most widely used.

Barb wire is available in gauge sizes of 12½, 13½, 14 and 15½. Two kinds of barbs are used in the manufacture of barb wire. These are two-point and four-point. Two-point barbs are usually spaced four inches apart, while the four-point barbs are spaced five inches apart. The barbs on some wire are wrapped around both strands. On others the barbs are wrapped around one strand. Barbs maintain their spacing better when wrapped around both strands. The amount of livestock pressure expected on the fence determines whether two-point or four-point should be used.

Smooth wire is used as a brace and to make the corner and brace posts rigid. It may also be used for constructing electric fences.

Transparency No. 4

Fence Fasteners - U-shaped and L-shaped staples are used to fasten wire fencing to wooden posts. The U-shaped staples are made from nine gauge wire and are 7/8 to 1 3/4 inches long. L-shaped staples may be purchased in lengths of 1 1/4 to 2 inches. Both galvanized and ungalvanized staples are available.

The length of staple to use depends upon the hardness of the wooden posts. The recommended staple length for treated soft wood posts, such as pine, is 1 1/2 to 2 inches. Based on recent research, the L-shaped staple has greater withdrawal resistance after the staple has been in the post for some time. The withdrawal resistance of the U-shaped staple decreases over the period of time it is in the post.

The proper method of using staples is shown in the above transparency. Although the L-shaped staple is not shown in the illustrations, they should be applied in the same manner as the U-shaped.

Galvanized wire fasteners are used to connect wires to steel posts. The fasteners are normally furnished by the dealer when the posts are purchased. There are several types of fasteners which are manufactured to be used on a particular post.

Galvanized steel wire is used to fasten the wires to concrete posts. A wire splicer can be used to twist the wire to the fence wire.

5. Laying Out the Fence Line and Right-of-Way

The information presented in this section applies to permanent fences, and it is assumed that the plans for the fences have been completed and their locations have been determined. Seldom does a farmer have the opportunity of laying out all of the fences on a farm, but he may change some of the existing fences to meet the needs of his farming operation.

The first step in laying out a fence is to clear the right-of-way of obstructions, which may include trees, brush, rocks, and debris. It may be necessary to remove the old fence and posts. If these are not going to be used in the new fence, the old fence may be removed and buried with a bulldozer.

Transparency No. 5

If the wire and posts in the old fence are to be used in the new fence, the wire should be detached from the posts with fencing pliers or a wrecking bar.

Steel posts may be pulled out of the ground with the hydraulic lift on a tractor. The best method for pulling wooden posts out of the ground is to use an "A" -frame constructed of 2" x 6" lumber. A chain is secured to the post just above the ground level, is placed over the "A"-frame, and is secured to a tractor drawbar. As the tractor is driven forward, the post is pulled out of the ground.

Transparency No. 6

The procedure for laying out a fence line where the right-of-way is cleared and the terrain is level is explained below:

1. A stake about seven feet tall is set in the ground at each end of the fence line. The stake should be vertical with the ground level and driven into the ground deep enough for it to be steady. A white cloth is tied to the top of each stake.
2. Stakes are aligned at 100 feet intervals between the two end stakes. One person stands at one of the end stakes and aligns the interval stakes, which are carried by another person. A tall stake is used for sighting and aligning, but a much shorter stake is used to mark the 100 feet intervals.

The procedure for laying out fence lines in hilly or valley areas is as follows:

1. Long stakes with a white cloth attached to the tops are driven at the ends of the fence line (A and B).
2. Two stakes with white cloth tied to the tops are placed about 10 feet apart at the top of the hill, or at the lowest point in a valley.
3. The two center stakes are aligned from one of the end stakes.
4. The alignment of the center stakes is then checked from the other end stake. It may be necessary to move the center stakes several times before they are aligned. A person sighting at both end stakes will speed up the aligning process.

The following explanation gives the procedure for establishing a fence line in undergrowth:

Transparency No. 7

1. A pole 15 to 20 feet in length is set in the ground at the end of the fence line nearest to the underbrush. The pole should be long enough to be sighted from the other end of the fence and should be vertical to the ground.
2. A second stake is aligned with the end stakes as far into the underbrush as can be sighted.
3. Underbrush is cleared between the stakes that are in the underbrush.
4. If necessary other stakes are aligned in the underbrush before clearing more brush.

Transparency No. 8

The instructions given below are for constructing fences on the contour. The fence may be at the bottom of a terrace, along an irrigation canal, on the bank of a stream, or between strip crops.

1. The fence line is staked by placing stakes 16 feet apart.
2. Where the fence line makes a curve, three stakes are set.
3. A string line is drawn between the first and third stakes.
4. The distance between the string and center stake is measured. If the distance between the string and center stake is less than four inches, the posts may be spaced 16 feet apart. If the distance is more than four inches, the following spacing for posts should be used:

Distance from Center Stake to String Inches	Post Spacing Feet
4 to 5	15
5 to 6	14
6 to 8	12
8 to 14	10
14 to 20	8

The fence should make a uniform curve, as a uniform curve will cause the wire to have an equal amount of tension on each post.

Another method used to lay out a straight fence line is to place the corner posts at the ends of the fence line and tightly stretch a wire between the posts. The wire is used to align the stakes and is loosened and pulled aside to dig the post holes. The wire may be used as one of the fence wires.

6. Constructing the Fence

The corner (anchor) and brace posts and the brace are the foundation of the fence and are important to the life expectancy of the fence.

Transparency No. 9

Holes for anchor or corner posts should be 3 1/2 to 4 feet deep or deeper depending upon the type of soil and the method used to secure the posts. Posts set in concrete may be placed in shallower holes. If posts are set in concrete, the concrete should be allowed to dry before attaching the wire to the post or before placing stress on the posts by any means.

Posts should be placed in the center of the holes in order that the soil around them may be tamped uniformly. Each shovelful of soil added to the hole is tamped around the post. As the soil is being tamped around the post, the post should be checked periodically to make sure it is vertical with the ground.

If steel anchor posts and braces are used, they should be set in concrete. A large amount of concrete should be placed around the corner posts and braces.

After the corner post has been set, the brace post is set next. The distance between the anchor and brace post is measured with the brace and should be a minimum of eight feet. The longer the brace the more strength the anchor and brace assembly will have. The hole for the brace post is dug, and the brace post is placed in the hole, but is not tamped. The hole for the brace post should be a minimum of 3 1/2 feet deep. If metal dowels are used to hold the brace in place, holes are drilled in both ends of the brace and in the two posts. If the brace is going to be placed in notches in the posts, the notches are measured and cut, and the brace is placed in the notches. Soil is placed around brace post and tamped.

The next step is to drive staples about four inches from the ground level in the anchor post and four inches above the brace on the brace post. Nine gauge smooth wire or barb wire is threaded through the staples, and two complete loops are made around the posts with the wire. The wire is pulled tight, and the loose ends are tied. A metal rod or stick is used to twist the wire until the wire becomes tight and the anchor and brace assembly is rigid.

Transparency No. 10

Different kinds of anchor and brace assemblies are shown in the above transparency. The type of assembly to use depends upon the length of the fence. If the fence is longer than 10 rods, the two-span end is recommended. Also, the two-span assembly is recommended for constructing line post brace assemblies.

Setting Line Posts - After holes have been dug, the line posts are aligned by sighting from one end, or by holding the posts against a wire that has been stretched between the two end posts. Depth of holes for the line posts is two to 2 1/2 feet. The recommended spacings for line posts on different kinds of fences are as follows:

Barb wire - 12 to 14 feet
Woven wire - 15 to 16 feet
Board fence - 5 to 8 feet
Suspension fence - 50 to 80 feet

Steel posts may be driven into the ground with either a power or hand operated driver. The wire holding studs are turned to the fence side when the posts are driven in the ground.

Transparency No. 11

Stretching Woven Wire - The roll of woven wire is placed with the close mesh end next to the post line.

1. The wire is rolled out to a length of about three line posts and is set on the close mesh end.
2. The first stay wire on the end is cut, loosened, and removed from the end of the line wires.
3. The bottom line wire is stapled into position. It should be about one inch above the ground if barb wire is not going to be placed under the woven wire. If barb wire is to be placed below the woven wire, the woven wire should be placed about three inches above the ground level.
4. The rest of the line wires are stapled into position from the bottom wire to the top.
5. Each line wire is pulled around the post and tied back to itself.
6. The rest of the roll of wire is unrolled to the next line post and brace assembly. It may be necessary to splice two of the rolls of woven wire together. This is accomplished by removing the stay wire to allow about four inches of line wire for the splice. The roll ends are pulled together until the stay wires meet, and the corresponding wires for each roll are tied to each other. Another method of splicing is to slip a metal sleeve over the wire ends and crimp the wires to the sleeve.
7. A dummy post is installed at the end of the fence line.
8. A clamp bar is attached to the fence, and a fence stretcher is attached to the bar and the dummy post.
9. The fence is tightened until about one-third of the tension curve has been removed from the wire. The exact amount of tension curve to remove will depend to some extent upon the weather.
10. The wire is attached to the anchor post with staples.
11. Enough stay wire is removed to allow the line wires to be pulled around the anchor post and to be tied back to themselves.

12. The middle line wire is cut and tied back to itself first. Then every other line wire is cut, pulled around the post and tied back to itself until all wires are cut and tied.

Stretching Barb Wire - Barb wire is fastened to the anchor post in the same manner as a line wire on a woven wire fence.

Barb wire is placed on the posts from the top wire down. This keeps the wires tight and prevents the other wire on the fence from becoming entangled as they are stretched.

The wire is unrolled down the side of the line post. To prevent kinks, the wire should be unrolled rather than looped off of the spool.

The wire is stretched with a fence stretcher at the opposite end of the fence. It is difficult to determine the amount of tension to place on barb wire, but it should not be so tight that it will break in cold weather.

After the barb wire has been stapled to the anchor post on the opposite end, one strand is cut, untwisted, pulled around the post, and tied back to itself. The other strand is then cut and tied back to itself and over the first strand.

The other wires are handled in the same manner. A jig made from a board and with nails driven in it at the proper wire spacings can be used to maintain the proper spacing between wires at each line post.

The number of wires used on a fence will determine the spacing of the wire. The following chart will assist one in determining the correct wire spacing.

Number of Wires	Fence	Distance Between Wires	Distance From Bottom wire to Ground
3-Wire fence	48"	16"	16"
4-Wire fence	46"	10"	16"
5-Wire fence	52"	10"	12"
6-Wire fence	52"	8"	12"

Some barb wire fences are reinforced with twisted-wire or other types of stays. Twisted-wire stays are recommended for suspension fences.

Fencing Across Ditches, Gullies, and Streams-Wire is stretched across low places when the fence is being construced, and later extra posts and wire or a structure, such as a water gate, are used to close the opening in the fence.

Transparency No. 12

Electric Fences - An electric fence is a temporary fence, which may be constructed of wooden or metal stakes and smooth or barb wire. The length of the electric fence will affect the decision whether to use an anchor and brace post assembly. Normally, the stakes are spaced 30 to 40 feet apart. The distance the wire is suspended from the ground is determined by the kind of livestock to be confined. For cattle and horses, the wire should be 2 1/2 to 3 feet from the ground. Swine require that the wire be only 1/2 to 1 1/2 feet from the ground. If two classes of animals, such as swine and cattle, are to be confined, a two-wire electric fence may be necessary.

To prevent the fence from becoming grounded, the wire is attached to insulators, which are attached to the posts or stakes. A screen door spring is often used to maintain tension on the electric wire(s) used for the gate. Also, an insulated handle is attached to the gate wire(s) to allow entry without being shocked. The gate wire(s) is usually spliced to a line wire by twisting a piece of line wire around the gate wire and in front of the gate wire insulator.

The electric fence controller should be Underwriter's Laboratory approved. The directions accompanying the controller should be read and followed.

Board Fences - If the fence is to be straight, a stake is driven at each corner, and a string is pulled tightly between the stakes. Post locations are located along the string at eight-foot intervals. The distance between the brace and corner posts may be less than eight feet; however, the distance should not be less than six feet. Holes for posts seven feet or longer should be dug a minimum of 2 1/2 feet deep because of the force of the wind on the fence.

After the post holes have been dug and it has been determined that the posts can be aligned, the posts can be placed in the holes and the soil tamped around the posts. The vertical position of the posts should be checked as the soil is being tamped. If the builder wants all of the posts to be the same height without having to cut them off at the top, a string may be fastened to the tops of each of the corner posts and the hole depth adjusted to give the post the proper height. Some holes may have to be dug deeper, while soil may have to be placed in the bottom of some holes. If soil is added to a hole, it should be tamped before placing the post permanently in the hole. It would probably be easier to saw the posts to the proper height after they have been tamped, particularly if a chain saw is available.

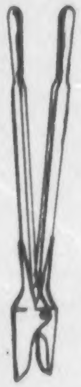
The board joints should be alternated on the fence. If the posts are located on centers at intervals of eight feet, this is a rather simple matter. The first board should be 16 feet long, and the next board under the first board should be eight feet long. Other boards are alternated in the same manner.

References:

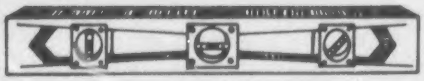
1. "Building Fences", American Association for Vocational Instructional Materials, University of Georgia, Athens, Georgia, 1974

2. Phipps, Lloyd J., Mechanics in Agriculture, The Interstate Printers and Publishers, Inc., Danville, Illinois, 1967

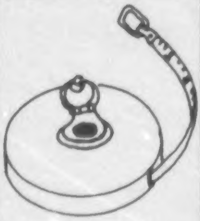
FENCING TOOLS



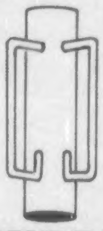
HAND DIGGER



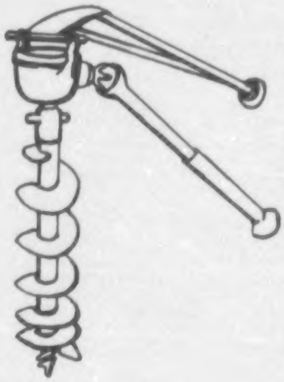
CARPENTER'S LEVEL



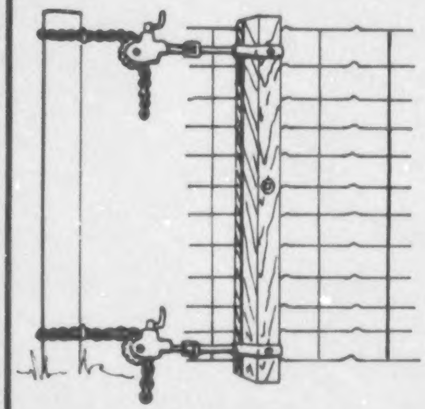
STEEL TAPE



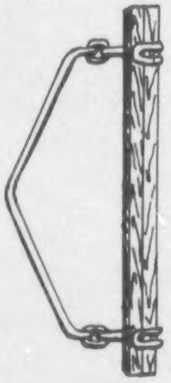
STEEL POST DRIVER



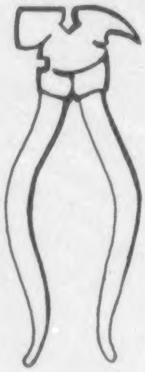
POWER DIGGER



DOUBLE JACK STRETCHER

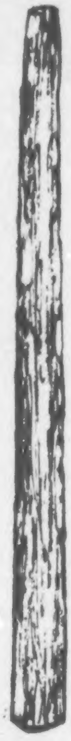


STRETCHING CLAMP

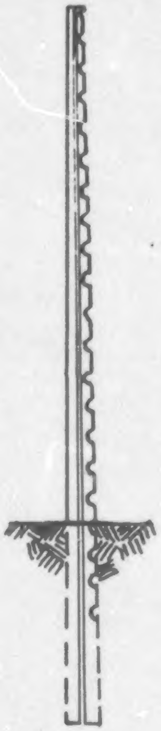


FENCING PLIERS

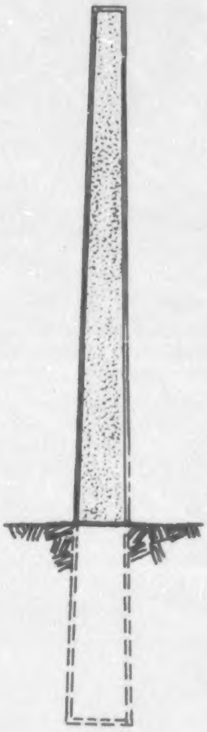
FENCE POSTS



TREATED WOOD

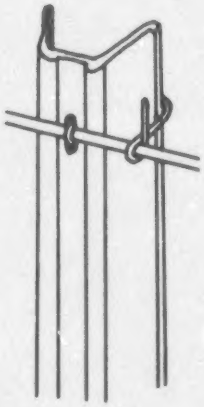


STEEL

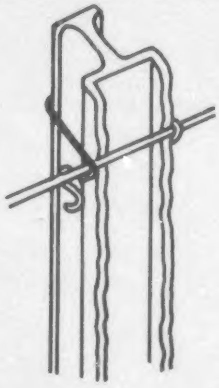


CONCRETE

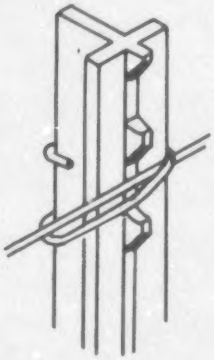
STEEL FENCE POSTS



"U" BAR

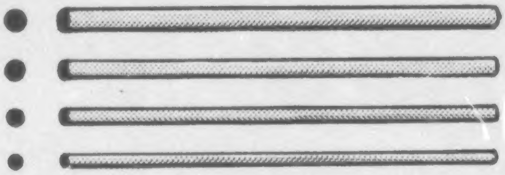


STUDDED "Y"

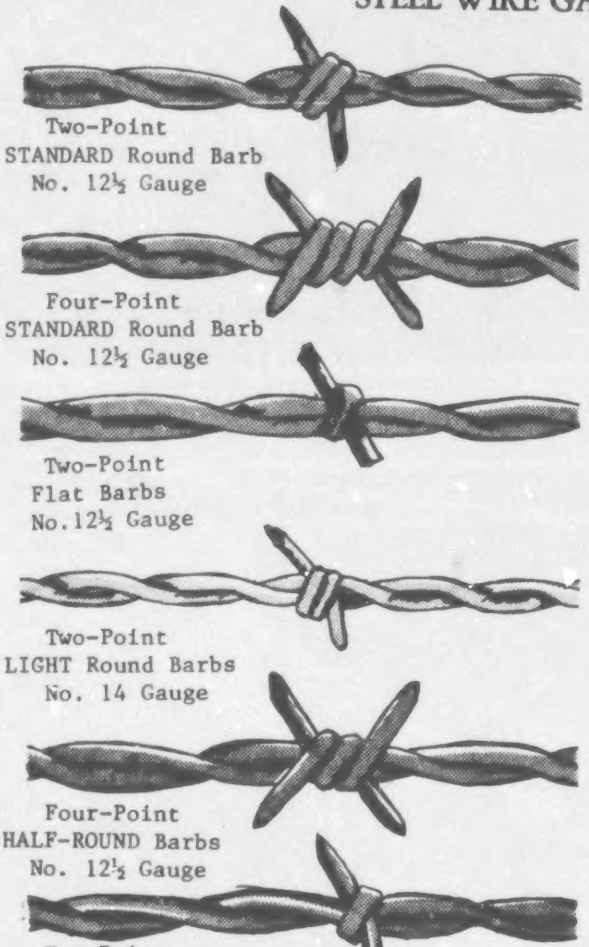


STUDDED "T"

WIRE & WIRE GAUGES



STEEL WIRE GAUGES



Two-Point
STANDARD Round Barb
No. 12½ Gauge

Four-Point
STANDARD Round Barb
No. 12½ Gauge

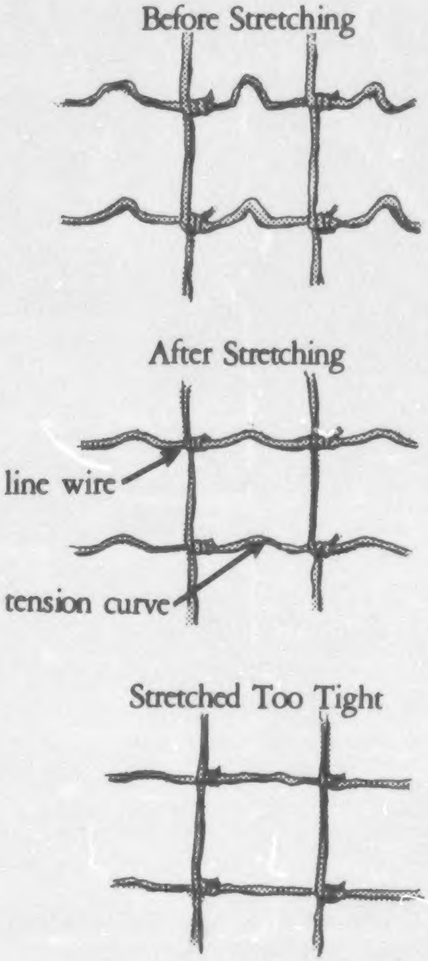
Two-Point
Flat Barbs
No.12½ Gauge

Two-Point
LIGHT Round Barbs
No. 14 Gauge

Four-Point
HALF-ROUND Barbs
No. 12½ Gauge

Two-Point
HALF-ROUND Barbs
No. 12½ Gauge

KINDS OF BARB WIRE



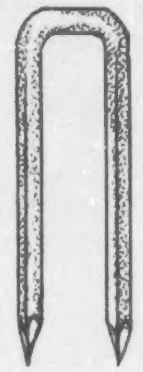
Before Stretching

After Stretching

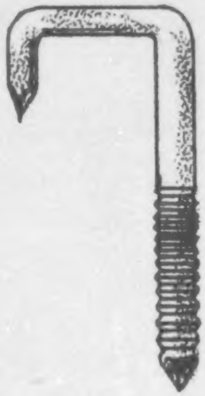
Stretched Too Tight

WOVEN WIRE

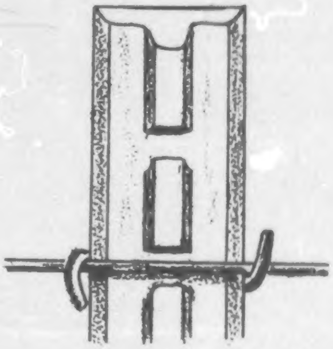
FASTENERS & THEIR USES



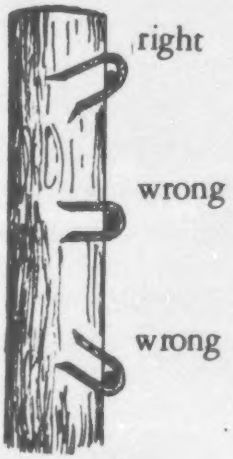
U-STAPLE



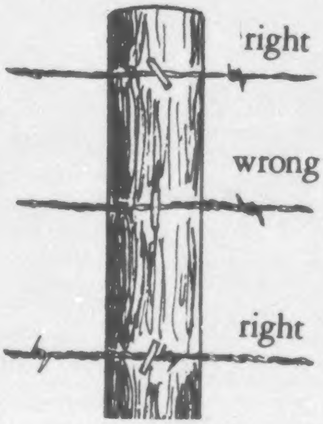
L-STAPLE



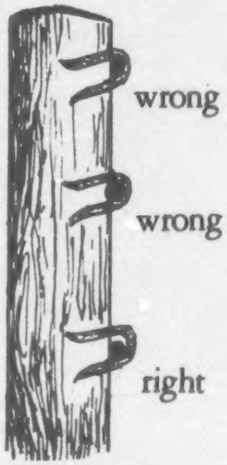
WIRE FASTENER


right
wrong
wrong

Drive staples
at an angle


right
wrong
right

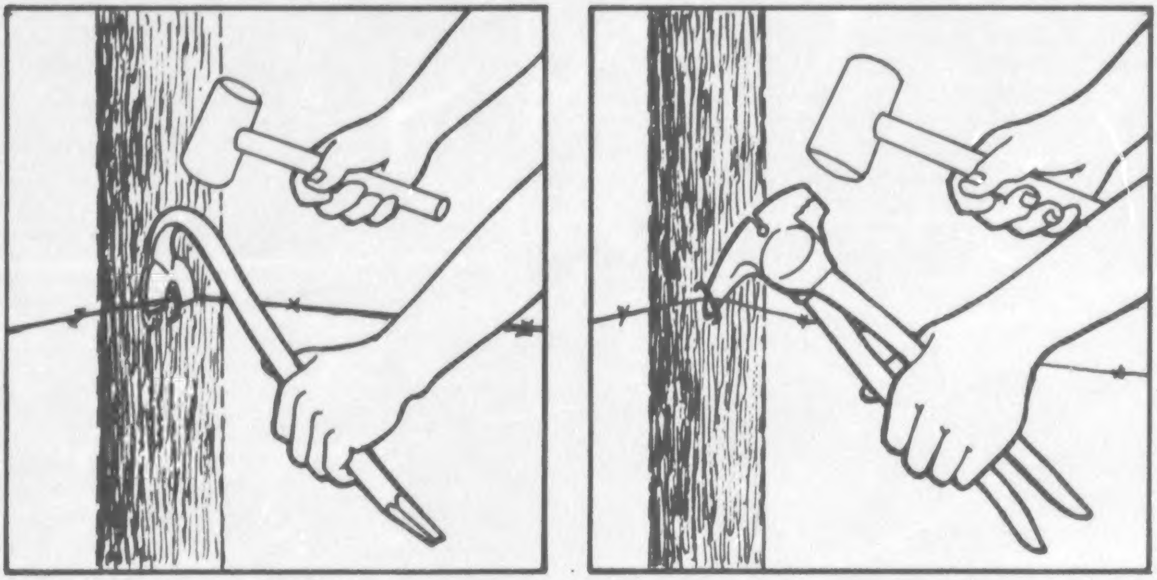
Do not drive staples
parallel to side of post


wrong
wrong
right

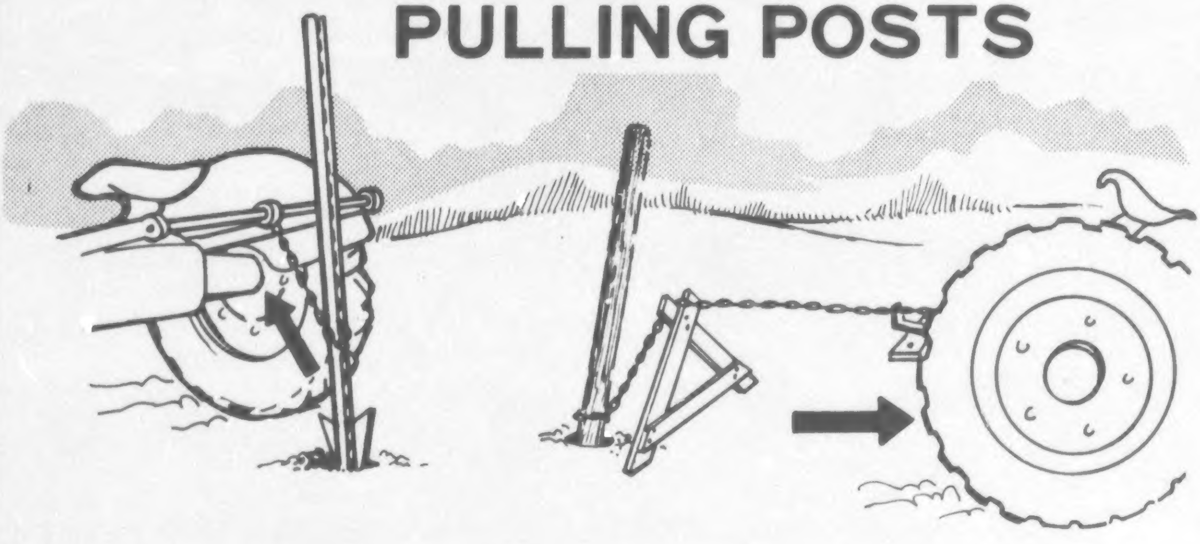
Leave wire loose
in the staple

RIGHT & WRONG WAY TO USE STAPLES

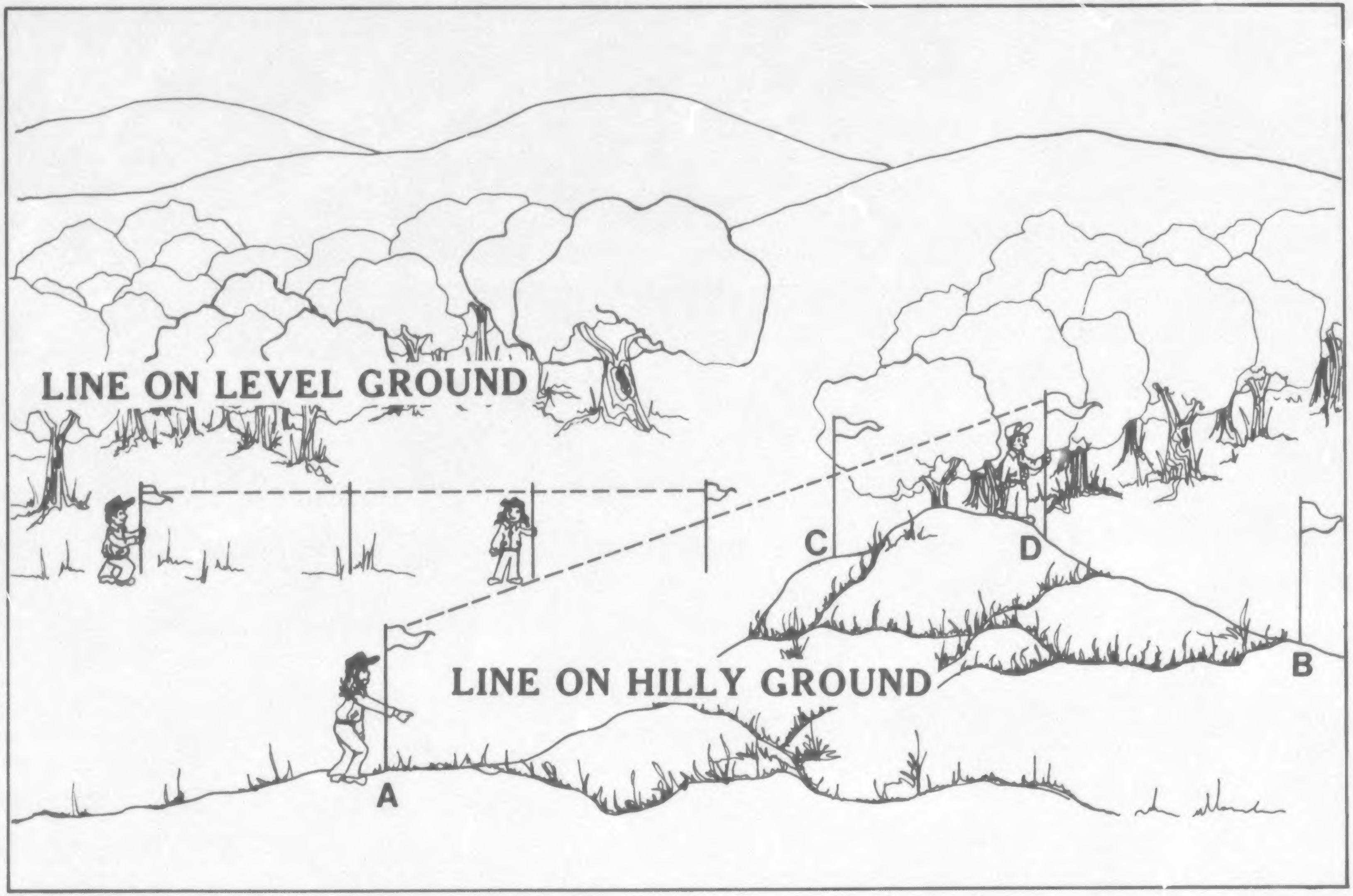
REMOVING WIRE



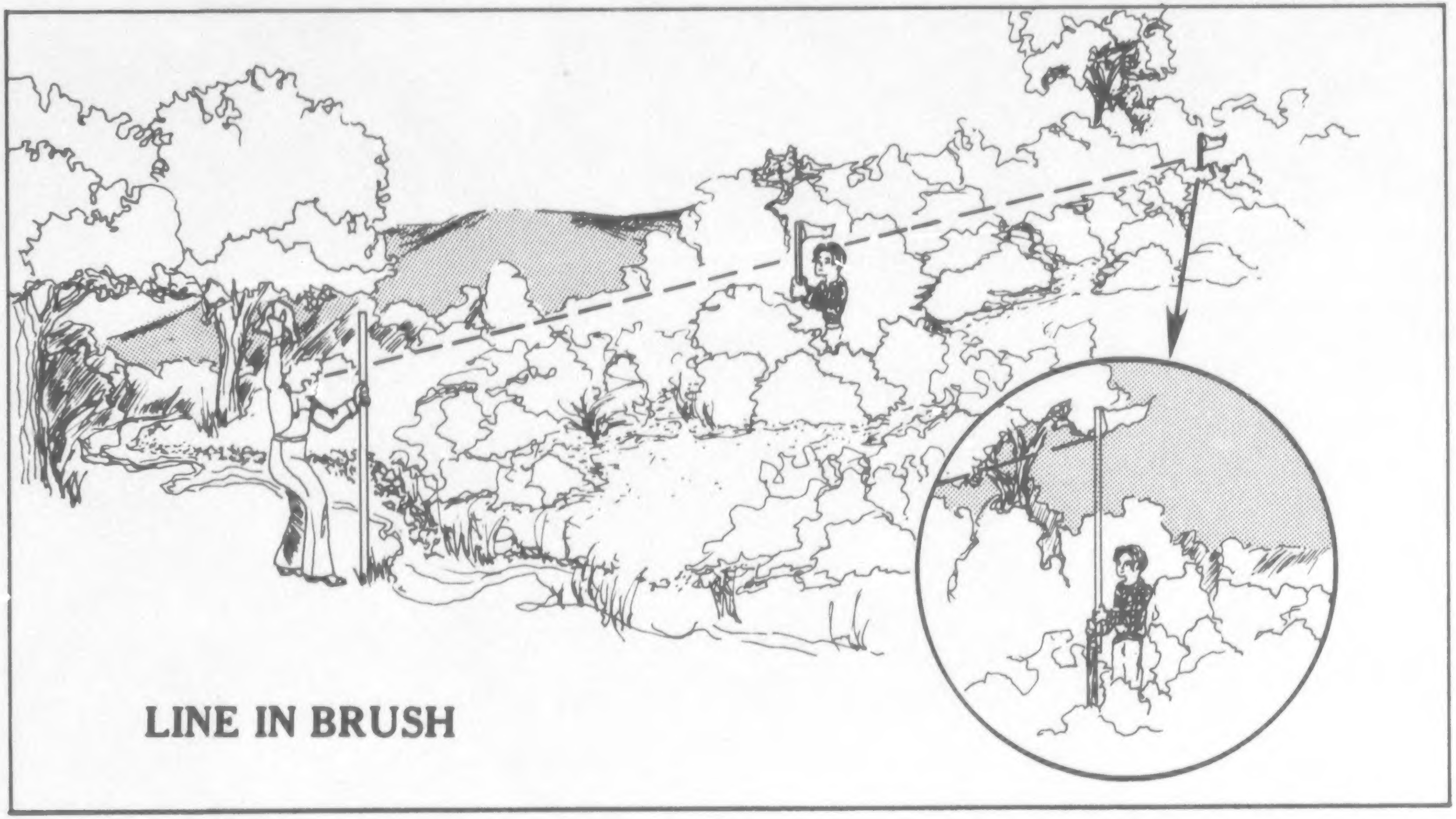
PULLING POSTS



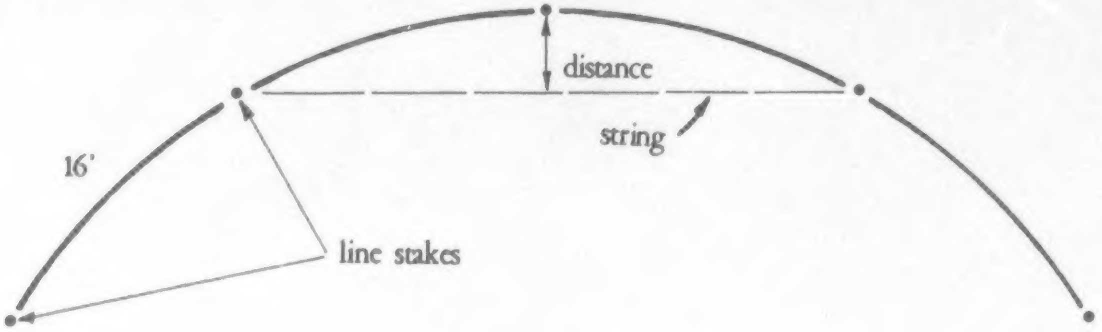
DETERMINING FENCE LINE


LINE ON LEVEL GROUND
C
D
A
LINE ON HILLY GROUND
B

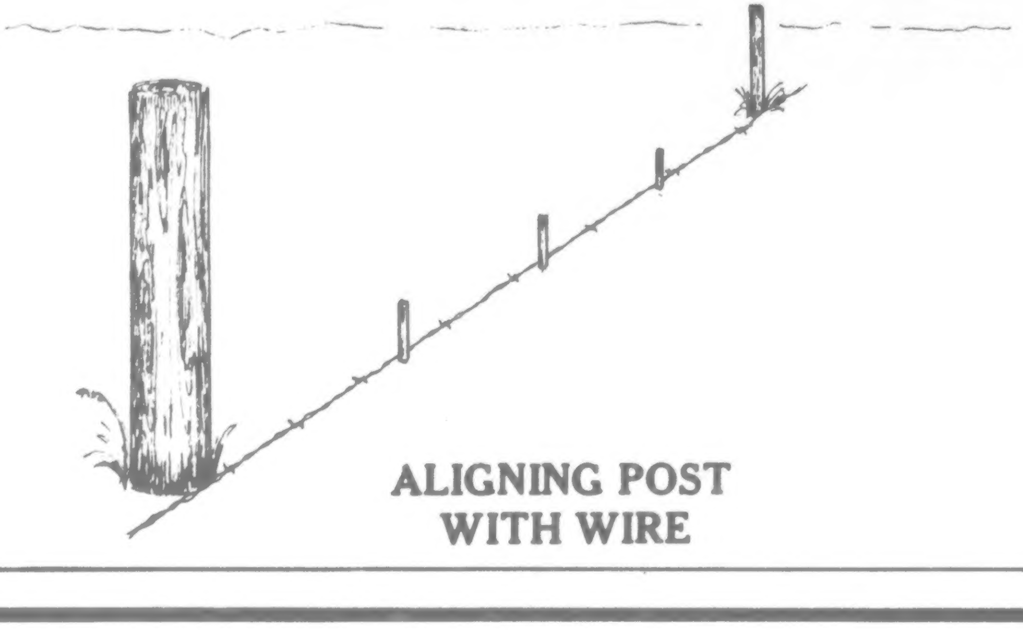
DETERMING FENCE LINE


LINE IN BRUSH

DETERMING FENCE LINE

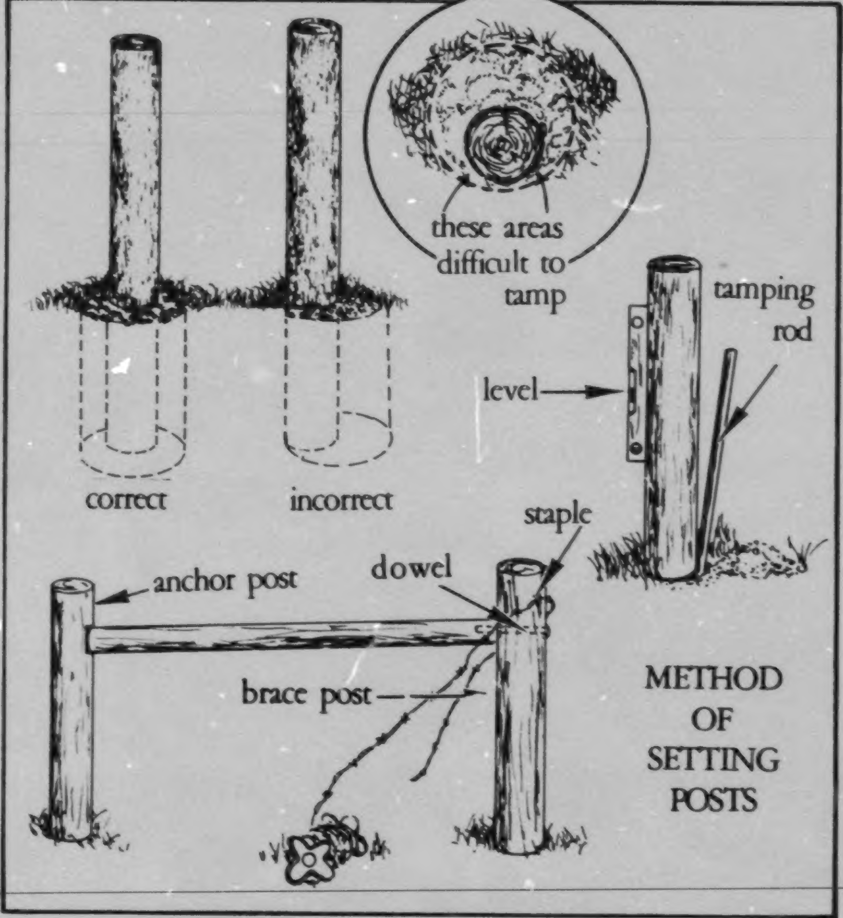

distance
string
16'
line stakes

LINE ON CONTOUR

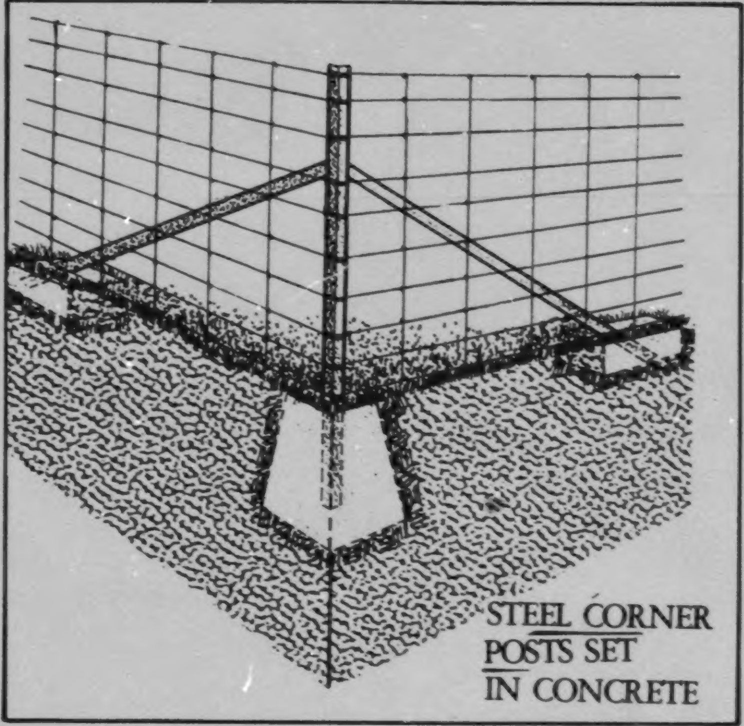


ALIGNING POST WITH WIRE

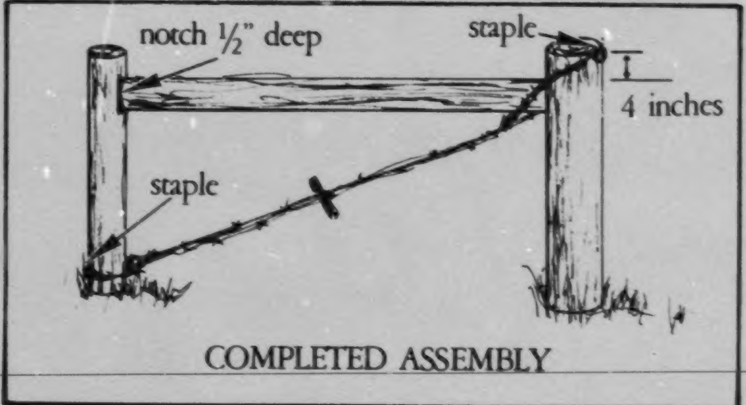
SETTING POSTS AND CONSTRUCTING ANCHOR ASSEMBLY


correct
incorrect
these areas difficult to tamp
tamping rod
level
staple
dowel
anchor post
brace post

METHOD OF SETTING POSTS

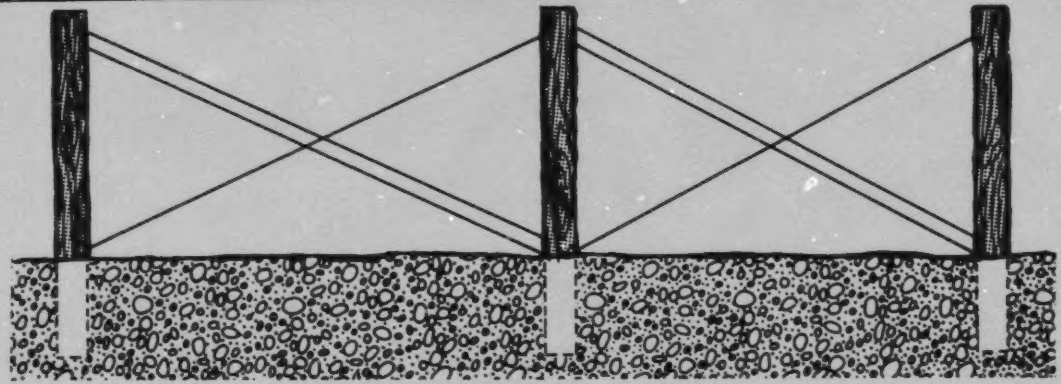


STEEL CORNER POSTS SET IN CONCRETE

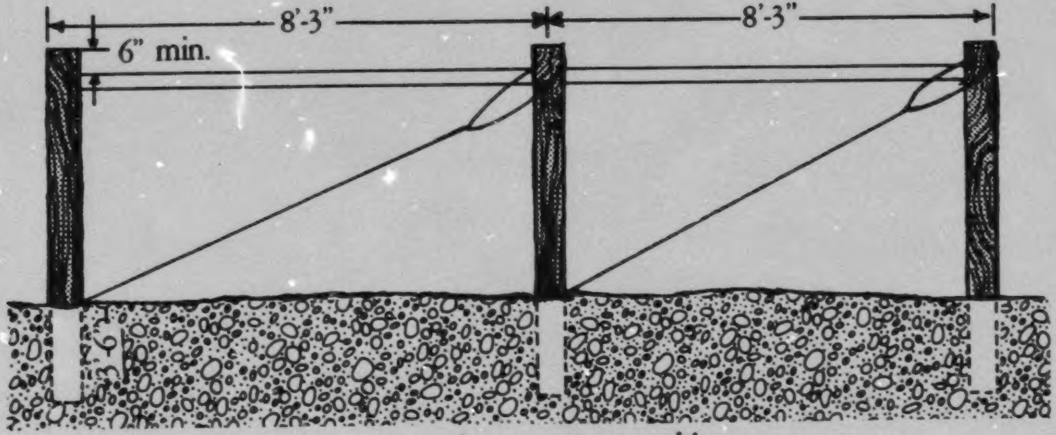

notch ½" deep
staple
4 inches
staple

COMPLETED ASSEMBLY

ANCHOR ASSEMBLIES

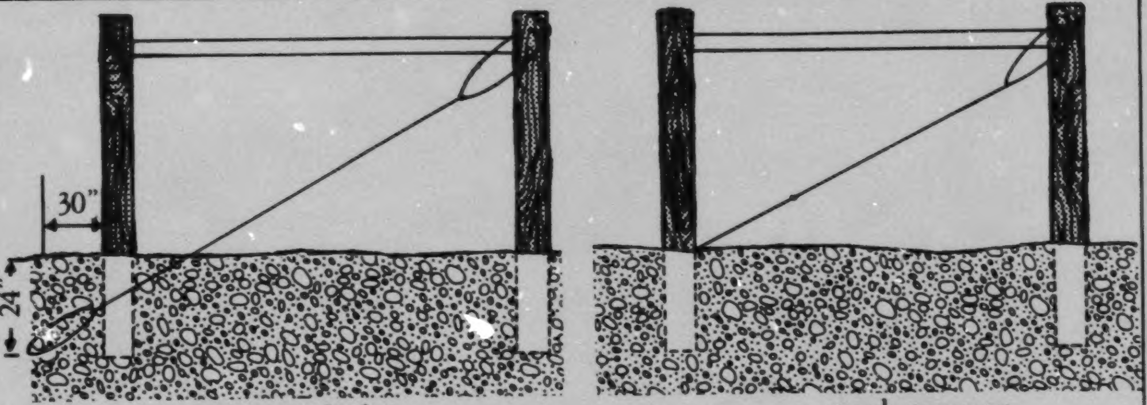


strongest assembly



second strongest assembly

TWO-SPAN ENDS



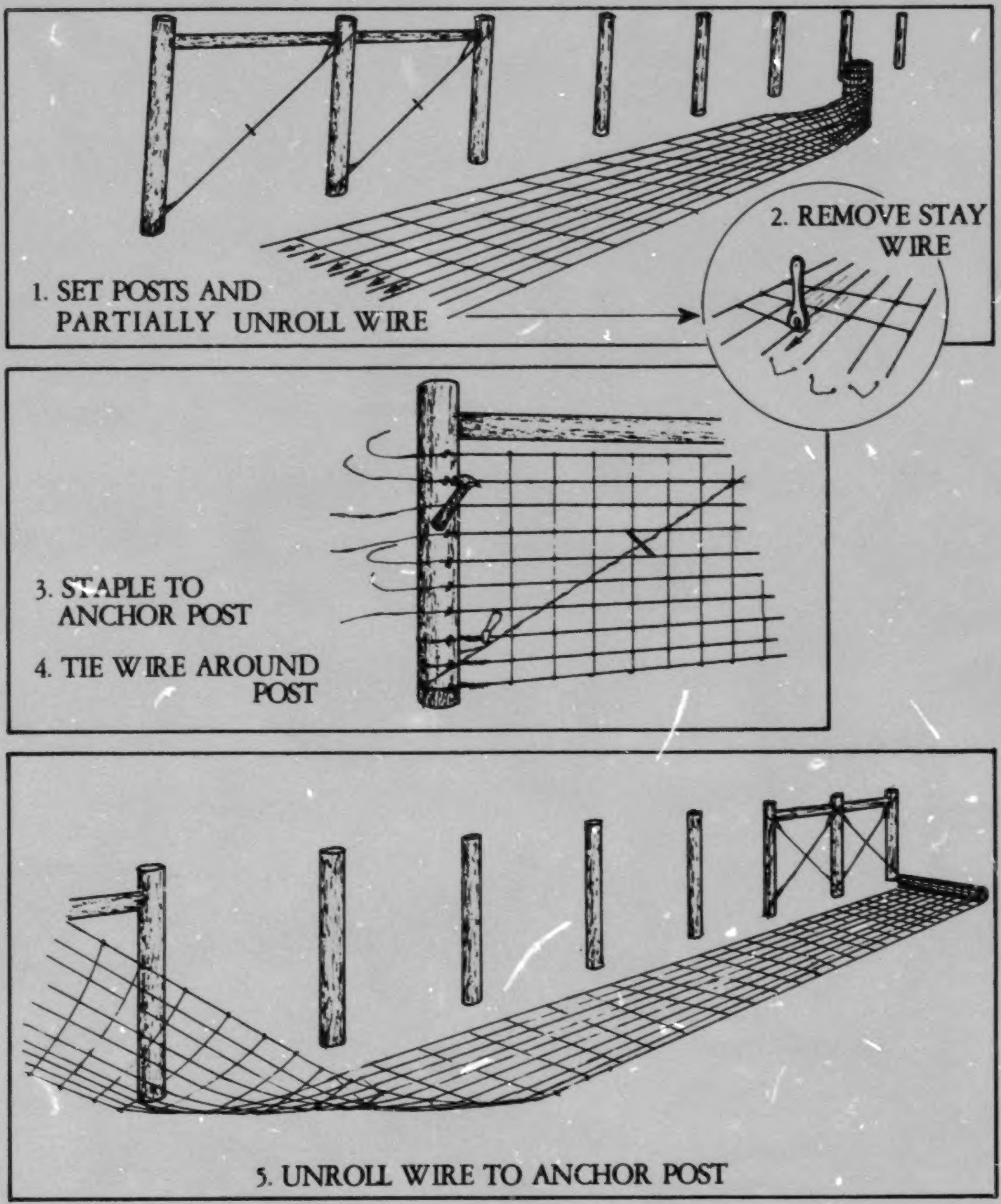
anchor

strongest single assembly

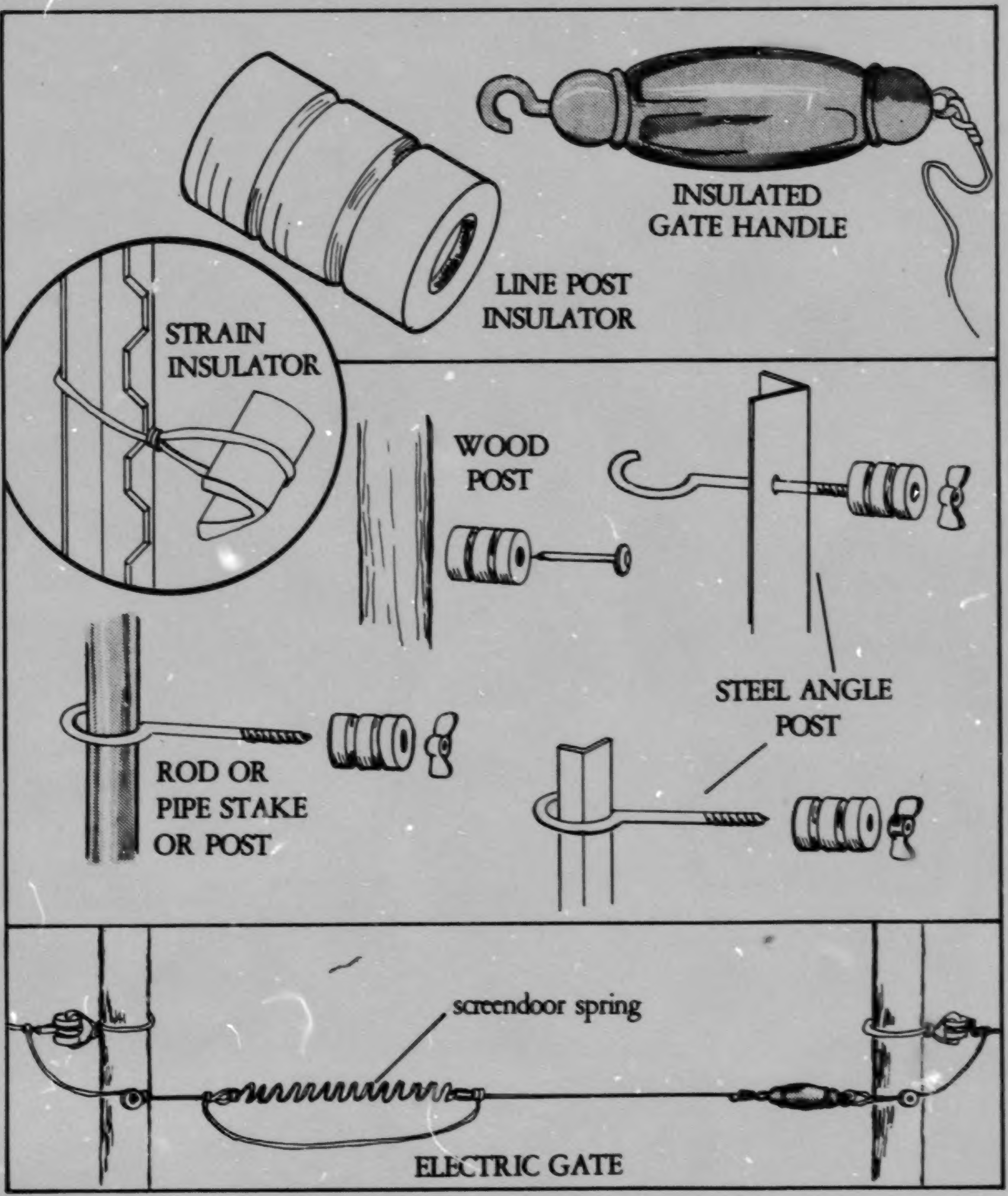
second strongest assembly

ONE-SPAN ENDS

STRETCHING WOVEN WIRE


1. SET POSTS AND PARTIALLY UNROLL WIRE
2. REMOVE STAY WIRE
3. STAPLE TO ANCHOR POST
4. TIE WIRE AROUND POST
5. UNROLL WIRE TO ANCHOR POST

ELECTRIC FENCE EQUIPMENT


INSULATED GATE HANDLE
LINE POST INSULATOR
STRAIN INSULATOR
WOOD POST
STEEL ANGLE POST
ROD OR PIPE STAKE OR POST
STEEL ANGLE POST
screendoor spring
ELECTRIC GATE

GENERAL AGRICULTURAL MECHANICS

Unit Q: Farm Structures

Topic 3: Using Concrete in Structures

1. Introduction

Concrete has been referred to as an artificial stone and is composed of a mixture of portland cement, sand, gravel, and water. It was used by the Romans to construct durable structures such as the Colosseum. However, during the Dark Ages, man lost the ability to make cement, a necessary ingredient in concrete.

In 1824, John Aspidin of Leeds, England, patented a product called portland cement. The name portland was given to the product by Aspidin because it resembled the color of the stone being taken from the quarries on the Island of Portland, just off the English Coast.

Portland cement is a type of cement and is not a brand name. It is manufactured by a number of competing firms in the United States. Portland cement is hydraulic, which means it will harden under water. A trade organization composed of manufacturers is called the Portland Cement Association. Its purpose is to promote the use of cement.

Portland cement is manufactured by applying an extremely high temperature--about 2700 degrees F.--to a mixture of lime, silica, iron oxide, and alumina. This causes the mixture to form clinkers, which are ground and mixed with a small amount of gypsum. The gypsum is added to control the setting time of the cement.

Mixing cement with water produces a chemical change, called hydration, which causes the cement to "set" and become hard.

Cement is available in bulk or in sacks. Sacked cement weighs 94 pounds and contains one cubic foot. A volume of one cubic foot is convenient for calculating materials in the making of concrete. The five most common types of portland cement are designated by Roman numerals. The types and uses of each type are given below:

Type I -	A general purpose cement that is used when a specific type is not needed.
Type II -	Used in areas requiring a low heat hydration, such as large piers, retaining walls, and heavy abutments.

Type III -	Used when a great deal of strength is needed the first two or three days it is placed. This type is used when forms must be moved shortly after the concrete is placed.
Type IV -	Used in areas where heat generation must be kept to a minimum. It develops strength much slower.
Type V -	A sulfate resistant cement used in areas exposed to sulfate action.

Another type of cement is air-entraining. This type contains evenly distributed air bubbles and is superior to other types when it is subjected to freezing and thawing.

Concrete is the most widely used building material because it is fireproof, termite and rodent proof, economical, permanent, sanitary, resistant to wear, will not decay, and requires very little maintenance.

The term aggregate is used when reference is made to the sand, gravel, pebbles, or crushed rock used in the concrete mixture. Aggregates are of two kinds, fine and coarse. Fine aggregate (sand) will pass through a 1/4 inch mesh screen, while coarse aggregate is 1/4 inch or larger.

2. Materials Used in Concrete

Good quality concrete is strong, durable, water tight, and resistant to abrasion. Factors affecting the quality of concrete are as follows:

1. Quality and amount of cement in the mixture;
2. Amount of water used;
3. Amount, kind, and grade of aggregate; and
4. Method of mixing, placing, and curing the mixture.

Water - Cement Ratio - Although all of the above factors affect the quality of concrete, the single most important factor is the quality of the portland cement paste. Paste quality is affected by the amount of water mixed with the cement, or the water-cement ratio. The cement paste might be compared to glue. When mixed with the aggregrate, it binds the particles together. If poor quality cement paste is used, the concrete will be of poor quality.

The water-cement ratio is expressed as the number of gallons of water per bag or cubic foot of cement and affects all of the desirable characteristics of concrete, which include durability, watertightness, strength, and resistance to abrasion.

In durability tests, it was determined that a water-cement ratio of 6 : 1 (6 gallons of water to one sack of cement) required 200 freezing - thawing cycles to reduce the weight of concrete by two percent. Only 80 freezing-thawing cycles were required for the same amount of disintegration with a water-cement ratio of 8 : 1.

Water-cement ratio and curing also affect the strength of concrete. Tests conducted on concrete samples after 28 days of curing revealed that concrete with a 5 : 1 cement-water ratio had 5,000 pounds per square inch of compression strength, while a ratio of 7 : 1 had only 3,300 pounds. The proper curing of concrete in only the first seven days can increase its strength as much as 50 percent.

General recommendations for water-cement ratios and concrete uses are given in the following transparency.

Transparency No. 1

Aggregate Size - After the cement-water ratio has been determined, the next consideration is the amount and size of aggregate. The grade and size of aggregate used in a mixture affect the economy, porosity, workability and shrinkage of the concrete. A mixture having too much aggregate will be stiff and require more labor to place. Concrete mixes should always be of a consistency and workability suitable for the job.

Concrete that molds readily and changes form slowly if the mold is removed immediately is referred to as being plastic. Most concrete work requires a mixture with a plastic consistency. A plastic concrete flows sluggishly without segregating and does not crumble. An extremely stiff and crumbly mix, or a watery, soupy mix is not considered to be plastic.

The aggregate in concrete accounts for 60 to 80 percent of the mixture, and a ton is from 20 to 22 cubic feet. Sand, gravel, and crushed stone are the most inexpensive and the most commonly used aggregate. Aggregate should possess the following characteristics:

1. Abrasion resistant - it should be hard.
2. Resistant to freezing and thawing - It should have very little pore space for the absorption of water.
3. Chemical stability - The aggregate should not react chemically with the cement.
4. Compression strength - Aggregate should be resistant to compression strength.
5. Particle shape and surface texture - These greatly influence the properties of fresh concrete. Round or cubical aggregates require less cement paste.

Dirty aggregate in a concrete mixture will cause it to harden slowly, or may prevent it from hardening. Therefore, the aggregate should be free of dust, loam, silt, clay, and vegetable matter.

Factors affecting the size of aggregate used in a concrete mixture are (1) Size and amount of reinforcement to be used (The aggregate should be of a size that will not require more than 3/4 of the space between the reinforcement and the forms), (2) The amount of water required to produce the desired slump (The smaller the aggregate, the greater the amount of water that will be required), and (3) Strength of concrete desired (About 3/4 inch aggregate is the maximum size that may be used in concrete requiring maximum strength).

Testing Aggregate for Quality - When fine aggregate of an unknown quality is available, a simple test may be conducted to determine if it is usable without being washed. Fill a quart jar to a depth of two inches with the aggregate. Then enough water is added to fill the jar 3/4 full. A water tight lid is placed tightly on the jar, and the contents are shaken vigorously for one minute. During the last few seconds, the jar should be shaken sideways. The jar is placed on its bottom and allowed to stand for one hour. Silt will be present in a layer about the sand. A silt layer of more than 1/8 inch is not satisfactory to be used in a concrete mixture without washing it and removing the silt.

3. Designing the Concrete Mixture

Economy, workability, and hardening qualities are the three considerations in designing the mixture. Since cement is normally the most expensive ingredient, the mixture should be designed to economize in this area. However, quality should not be sacrificed. Ways in which to economize are to use the least amount of water possible, use the largest aggregate possible, and use an optimum ratio of fine to coarse aggregate.

The first step in designing the mixture is to determine the water-cement ratio. Since this has been discussed above, it will not be repeated; however, the moisture in the aggregate must be considered.

Nearly all sands used in concrete contain some free moisture. Allowance must be made for the free moisture in selecting a water-cement ratio. The amount of free water in sand can be determined by observing and feeling of it.

Transparency No. 2

Damp sand will leave very little moisture on the hand, but it will feel slightly damp. Damp sand will fall apart when the hand is opened.

Wet sand will leave some moisture on the hand and will retain its molded form when the hand is opened.

Very wet sand will drip and leave considerable moisture on the hand. It will mold and hold its shape.

The chart in the above transparency can be used to determine the amount of water to use per sack of cement with sands having different degrees of moisture.

Coarse aggregate seldom has enough free water to be considered.

Several methods may be used in determining the amount of coarse aggregate to use in the mix.

One method is to following the recommendations of a builder, a cement dealer, or the Portland Cement Association. Another method is to make several trial mixes. The water-cement ratio is maintained while the sand and gravel are varied. In a mix appearing to be rocky and too wet, sand should be added. Gravel is added if there appears to be an excessive amount of paste (mortar).

The following may be helpful in determining the amounts of fine and coarse aggregate to use in a mixture:

Aggregate Size	Portion in Mix
1/4-1/2 inch	Equal parts of sand and gravel
1/4-3/4 inch	Use 3/4 as much sand as gravel
1/4-1 1/2 inch	Use 1/2 as much sand as gravel

When the mix appears to contain the proper proportions, a slump test is conducted. The purpose of this test is to further test the consistency of the concrete.

Transparency No. 3

It may be necessary to conduct several tests and to vary the mixture to acquire the proper mix. The procedure for making the test is as follows:

1. The mold is placed on the solid board;
2. Mold is filled about two-thirds full with concrete;
3. The metal rod is used to give about 25 strokes to the concrete with the pointed end (bullet point);
4. About one-half of the remaining space in the cylinder is filled with concrete and is rodded 25 times;
5. The remaining space in the cylinder is filled with concrete and rodded 25 times;
6. The mold is removed by gently raising it vertically; and
7. The mold is placed beside the slump pile of concrete and the slump is measured. The center of the slump is the point to measure.

The maximum recommended slump for various concrete uses is given below:

	Max. Slump in inches
Foundation walls with reinforcement	4"
Slabs, beams, and walls w/reinforcement	5"
Pavement	2"
Sidewalks and driveways	4"

If the slump is greater than the maximum allowable, small quantities of fine and/or coarse aggregate may be added. For too little slump, it may be necessary to add water.

The following are some commonly used concrete mixtures:

Cement	Sand	Gravel
1	2	3
1	2	4
1	2 1/2	5
1	3	5

4. Calculating the Materials

Transparency No. 4

In the mixing of cement, sand, and gravel, the smaller particles fill the spaces between the large particles. Because of this, a greater volume of materials is required to fill a given volume of space. Based on experimentation, "Fuller's" rule was developed. The rule states that a total of 42 volumes of cement, sand, and gravel when combined will produce 27 volumes of concrete.

Transparency No. 5

The above transparency is an example of how Fuller's rule is used in calculating the materials used for a given job.

5. Ready-Mixed Concrete

Ready-mixed concrete is available in many areas. Before deciding to purchase ready-mixed concrete, one should determine the cost of purchasing the materials and mixing the concrete on the job. The convenience of using ready-mixed concrete may offset a small saving in job mixing.

An allowance should be made for concrete wastage when ordering ready-mixed concrete. The following formula is a fairly accurate means of determining the amount of concrete to order:

1. Surface area is determined by multiplying the length times the width; and
2. Formula provided below is used:

Divide area by:	For concrete thickness of:
300	1 inch
100	3 "
75	4 "
50	6 "
25	12 "

An example using the dimensions of the sidewalk in the above example is given below:

6' x 100'= 600' surface area (sq. ft.)
600 ÷ 75 (4 inch thick concrete) = 8 cu. yds-amount
of ready-mixed concrete to order

6. Concrete Forms and Reinforcements

Forms are used to hold the concrete in place until it has hardened. Rough lumber may be used in the construction of the forms if the appearance of the concrete is not important. Smooth lumber, such as tongue and groove and plywood, is used when a smooth surface is desired. Good forms will possess the following characteristics:

1. True to shape and size;
2. Adequately braced to prevent bulging, sagging, and spreading;
3. Tight and free of openings to prevent leaking; and
4. Easily removed.

Because of individual preferences and the differences in structures, various kinds of forming systems are used. The kind of forms used will depend upon the availability of commercial forms and whether the lumber used in the forms will also be used in the structure.

Transparency No. 6

The "built in-place" forms are the most extensively used for farm structures. However, manufactured forms are available on a rental basis in a number of areas.

Built-in-place forms are normally constructed of 2" x 4" vertical members with tongue and groove boards or plywood nailed to the members. The forms are held in place with ties. Vertical members, ties, spreaders, and walers are spaced unformly to take a maximum load at all parts of the form. Wire ties and spreaders are not as satisfactory as some of the manufactured ties.

The snap ties are the most popular because the tie is broken at the breaking point and left in the concrete, and they are much easier and quicker to install.

Removing Forms - The weather, temperature, mass of concrete, and the area in which the concrete is placed determines the length of time the forms are left in place. In warm weather, the forms should be left in place at least three days. Forms should be left twice as long in cold weather. In any case, the concrete should be thoroughly set before removing the forms. Leaving the forms in place a week will aid the curing process, as they prevent the concrete from drying as fast.

Reinforcing Concrete - The purpose of reinforcing concrete is to increase its tensile strength. Concrete can withstand compression, but reinforcement must be added if loads or force are applied which cause it to bend or be pulled. Concrete has about 10 times more compression strength than it does tensile strength. By using reinforcement properly, its tensile strength can be made to exceed its compression strength.

Placement of reinforcement in concrete will depend upon the location where stress will be applied. For example, the pressure on a beam, such as a lintel over a door or window, is near the lower side. In this case, the reinforcement should be placed on the lower side.

Transparency No. 7

Since steel has about the same contraction and expansion characteristics as concrete, it is almost universally used for reinforcing concrete. Steel reinforcement bars and wire mesh are the types generally used.

Several sizes and types of welded wire fabric are available. One type of fabric is referred to as 6 x 6 - 10 - 10. This means that the wire is spaced on six-inch centers both ways and both horizontal and vertical wires are No. 10 gauge. Both smooth and deformed steel bars are used; however, the smooth bars are usually of small diameter steel.

General recommendations relative to the use of reinforcement in concrete are as follows:

1. Only clean reinforcement should be used. It should be free from rust, paint, and scale;
2. The reinforcement should not be placed closer than 3/4 of an inch from the outside surface of the concrete;
3. Reinforcement should be placed in areas of tension, such as corners and joints;

4. Wire mesh and bars should be placed near the center of the concrete for slabs and sidewalks;
5. Reinforcement bars are lapped a minimum of 24 times their diameter and never less than 12 inches; and
6. An engineer's recommendation should be sought and followed on large concrete jobs.

7. Placing, Finishing, and Curing Concrete

Prior to placing the concrete, the inside of the forms should be painted with crude or crankcase oil to prevent the concrete from sticking to them. All of the concrete should be removed from the forms before they are used again.

The maximum amount of time between the mixing and placing of concrete is 1 1/2 hours; therefore, the site and the forms where concrete is to be placed should be ready before the concrete is mixed. In warm or hot weather, concrete should be placed within 30 to 60 minutes after it has been mixed. Jobs that need to be completed before placing concrete are compacting and moistening of the subgrade, erecting the forms, painting the forms with oil, and setting the reinforcement.

The placing of concrete should be as close as possible to its final position. As it is placed in the forms, it should be mechanically vibrated or tramped by hand with a spade or tamping tool. Spading the concrete next to the form is particularly important to prevent honeycombing on the sides. Tapping the forms in the areas that cannot be tramped will settle the concrete in these areas. The inexperienced builder is cautioned that concrete can be overworked. Evidence of overworking is the rising to the surface of water and the fine materials.

When large concrete slabs are being constructed, the placing of concrete should start at one end or side and each batch dumped against the previously placed concrete. The batches should not be worked together, and concrete should not be moved a great distance from its final placement. If each layer is thoroughly consolidated before placing the next layer, concrete can be placed in layers. When placing concrete in deep forms, the forms are filled to about one foot of the top and allowed to settle for about one hour before placing the last foot. However, the placing of the top foot should be resumed before setting occurs.

Transparency No. 8

Finishing Concrete - The finish on concrete will depend upon how the concrete is to be used. Several different kinds of finishes may be applied. Also various pigments may be added to color the concrete.

The first step in finishing concrete is to consolidate it. This gives the concrete a uniform, plastic mass; and is accomplished by tamping and using a strike-off board, virbrating screed, or jitterbug. Tampers and jitterbugs are used only when the concrete cannot be consolidated by other means.

Transparency No. 9

A straight 2 x 4 or 2 x 6 of the proper length may be used to strike-off. Striking-off is the moving of the board back and forth across the top of the forms to remove humps and hollows and to acquire an even surface. Vibrator screed, roller screed, or mechanical screed can be used for the same purpose. After a screed is used and water bleeds to the surface, the concrete is darbied or bull-floated to eliminate ridges and voids caused by striking-off.

Edging rounds the edges and keeps them from breaking off. The concrete is edged when it starts to stiffen. Marks left by the edger can be removed by floating, or they can be left for decorative purposes.

Joints are placed in the concrete to control cracking caused by expansion and contraction of the concrete. If the concrete cracks, it will crack at the joint, the weakest point in the slab. Joints are cut from 1/4 to 1/5 of the depth of the concrete with a trowel, jointer, or concrete saw and are spaced at 10 to 15 feet intervals in sidewalks and small jobs. A groover is used to finish the joints.

Concrete is floated to remove imperfections in its surface, to pack the concrete, and to raise mortar to the surface, which is necessary for the finishing operation. The proper time for floating is after the concrete has hardened enough to withstand a man's weight and leave only a small imprint. Wood, metal, or cork floats may be used in this step.

The final finish is given after the concrete has been floated. This finish is applied after the surface is fairly hard, yet still workable. Some different kinds of finishes are broom (used on driveways, walks, and feeding floors), burlap finish (a piece of rubber 6 to 12 inches wide is moved back and forth across the concrete), hand float finish (produces a gritty, non - slippery surface), and troweling (produces a smooth, dense surface). The troweling may be either by hand or mechanically. A decorative finish may also be applied.

Curing Concrete - The mixing of water with cement and the chemical reaction that follows, called hydration, causes concrete to harden. Proper curing increases the strength, durability, watertightness, and wear resistance.

Only about three gallons of water per sack of cement is required for hydration. More water is added to make it possible to place the concrete. Unless curing is commenced as soon as possible after finishing, proper hydration may not be obtained because of water losses due to evaporation and seepage. A rapid loss of water causes shrinkage and tensile stresses at the surface. If stresses develop before the concrete has adequate strength, cracks will form in the surface. Curing should be continued for several days, as the strength of concrete can be increased 50 percent during this period. Even a longer curing period, up to a month, will further increase the strength of concrete.

Transparency No. 10

Two methods are used to cure concrete: (1) Supply additional moisture and (2) Seal the surface to prevent moisture losses.

Additional moisture may be supplied by flooding, ponding, or mist spraying. Using the ponding method, a small earthen dam must be constructed around the perimeter of the concrete. If an intermittent sprinkler is used, the concrete should not be allowed to become dry.

To seal the surface, the concrete may be covered with plastic and straw, plastic, canvas, or wet burlap. These materials should be applied as soon as possible, but should not mar the surface. A chemical spray is now available in clear, white, black, and light gray colors. The surface is sprayed with the chemical which forms a plastic-type membrane over the surface and prevents evaporation. The spray is applied after the free surface water has evaporated.

The atmospheric temperature will affect the length of time concrete is cured. The most desirable temperature for hydration is 55 to 73 degrees F. Protection should be provided for concrete to prevent freezing for at least 24 hours after it has been placed; otherwise, it will be permanently injured.

References:

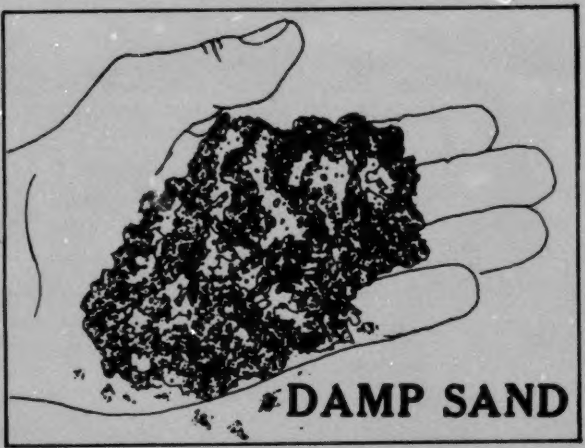
1. "Concrete Technology", Delmar Publishers, Albany, New York, 1965

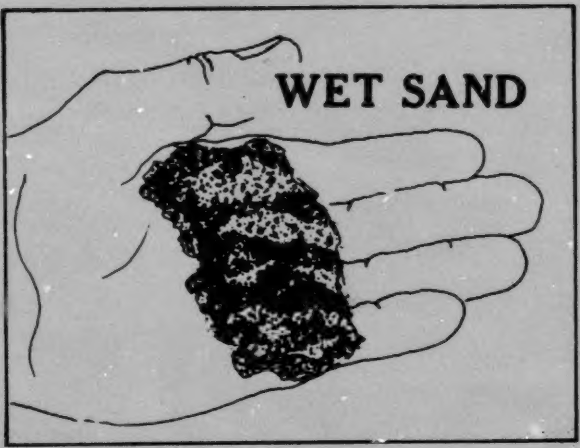
2. "Concrete - Suggested Lesson Plans for Teachers of Vocational Agriculture", The Department of Agricultural Education, Texas A&M University, College Station, Texas, 1960

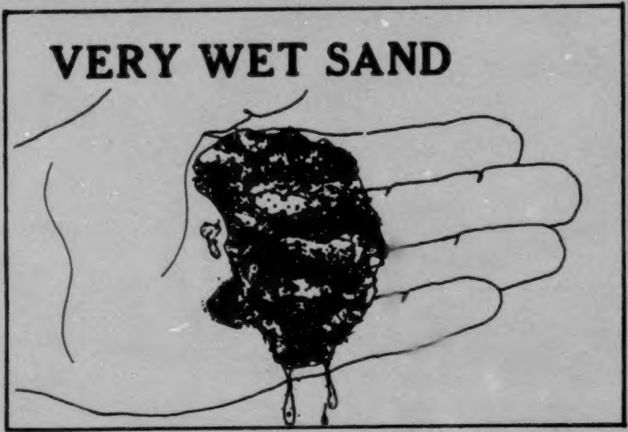
GENERAL RECOMMENDATIONS FOR WATER-CEMENT RATIOS

GALLONS PER SACK OF CEMENT:	CONCRETE SUBJECTED TO:	SUGGESTED AREAS OF PLACEMENT:
5	severe wear or weather, or weak acid and alkali solutions	topping for two-course work, one course industrial, creamery or cannery floors, thin sections of strong concrete, fence posts, and trench silos
6	moderate wear and weather, must be watertight	watertight floors, dairy barns, basements, watering troughs, vats, septic tanks, swimming pools, walks, paved feed lots, floor slabs, french silos
7	not subjected to wear, weather, or water	foundations, walls, footings, mass concrete, floor slabs, walks, feeding floors

DETERMINING FREE MOISTURE IN SAND



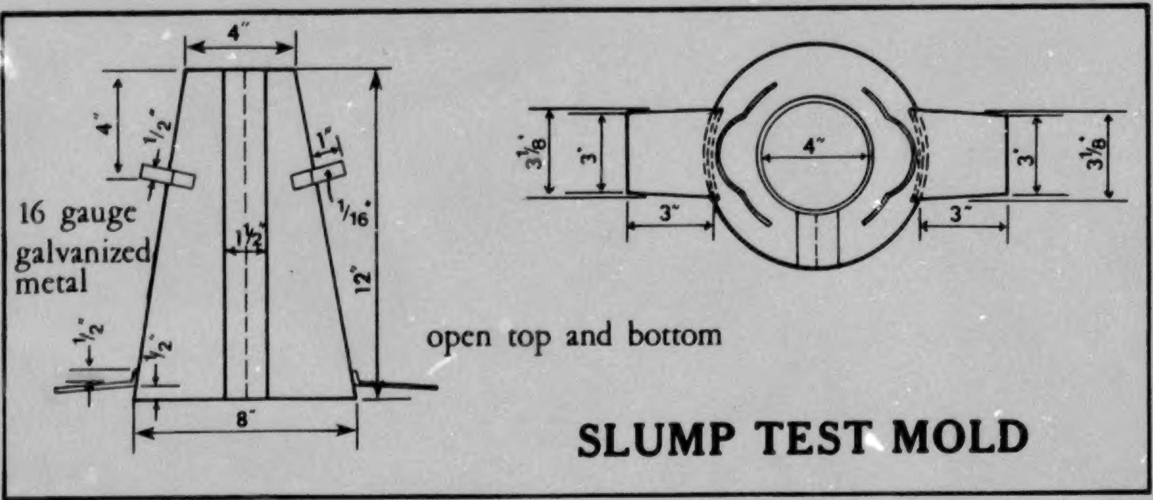




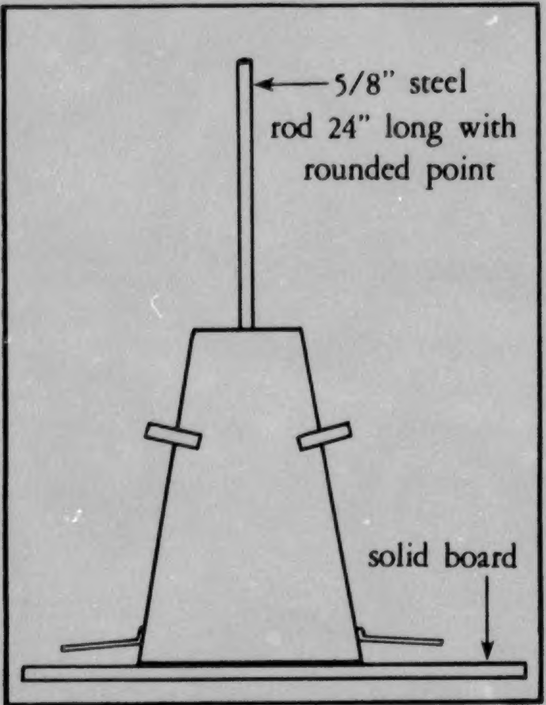
Amount of Water to Use on Sand with Different Degrees of Moisture

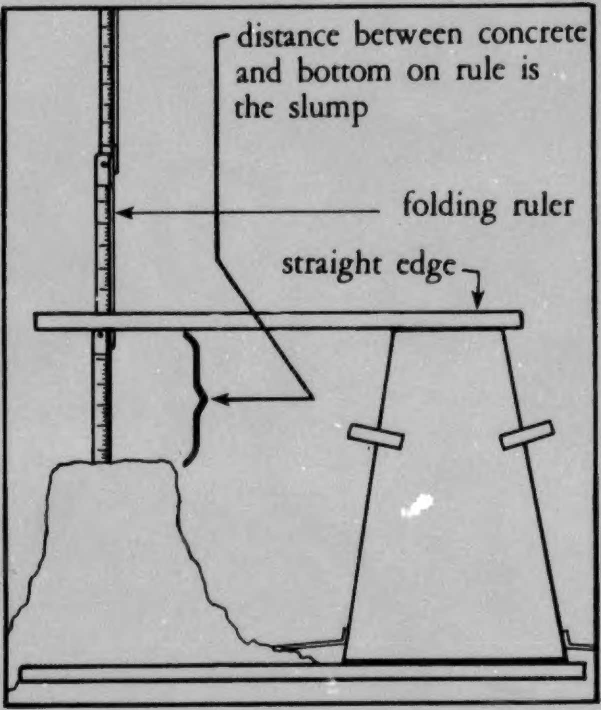
Water-Cement Ratio	Gallons of Water to Add to Sand With Different Degrees of Moisture		
	Very Wet	Wet	Damp
5 gal. paste	3 1/2	4	4 1/2
6 gal. paste	4	4 3/4	5 1/2
7 gal. paste	4 3/4	5 1/2	6 1/4

EQUIPMENT USED IN MAKING A SLUMP TEST

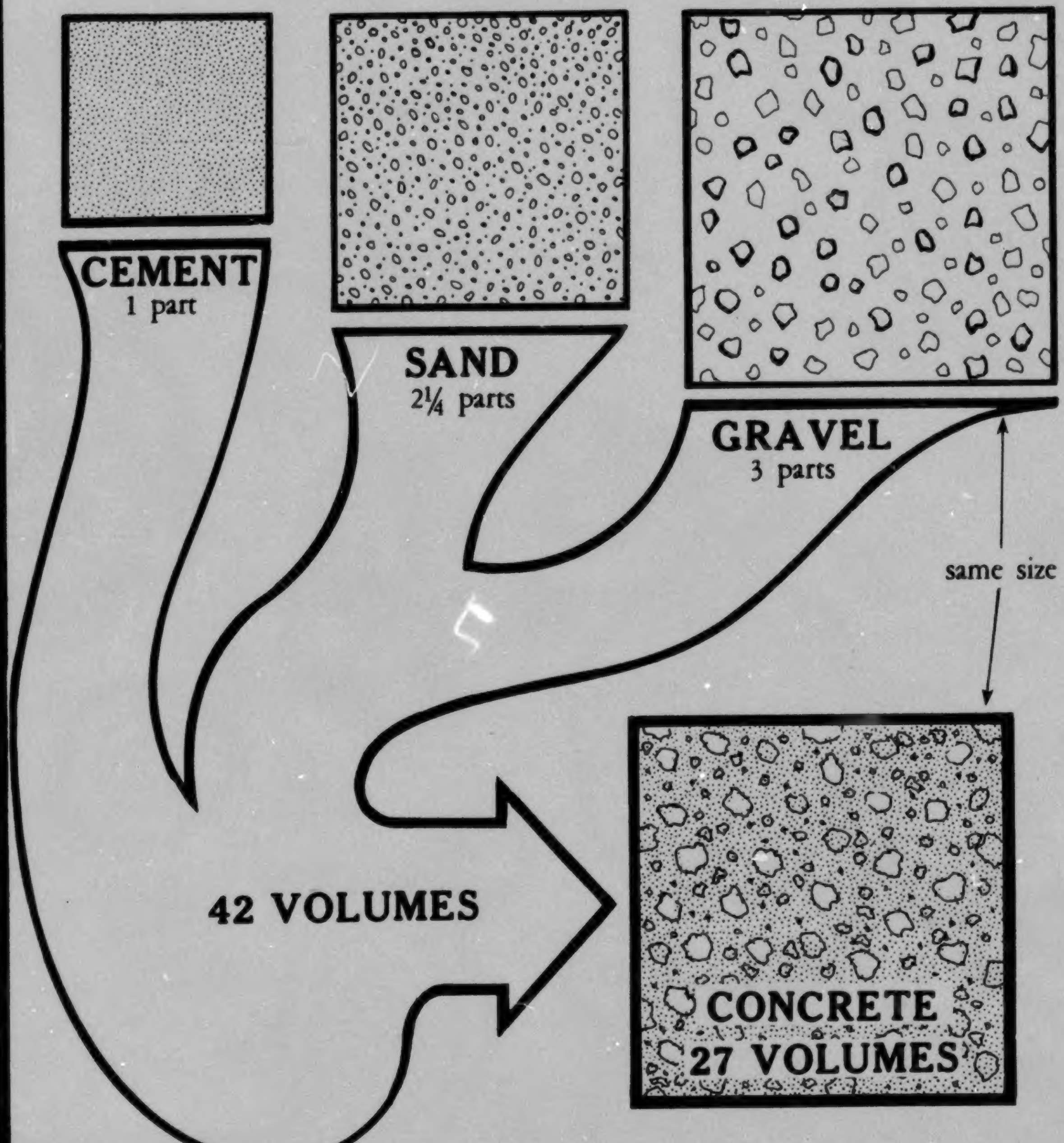

4"
4"
1/2"
1"
1/16"
16 gauge galvanized metal
1½"
12"
1/2"
1/2"
8"
3⅛"
3"
4"
3"
3"
3⅛"
open top and bottom

SLUMP TEST MOLD


5/8" steel rod 24" long with rounded point
solid board


distance between concrete and bottom on rule is the slump
folding ruler
straight edge

FULLER'S RULE


CEMENT
1 part
SAND
2¼ parts
GRAVEL
3 parts
same size
42 VOLUMES
CONCRETE
27 VOLUMES

MORTAR MIXES AND QUANTITIES OF MATERIALS

A 1-2-4 mixture of cement, sand, and gravel is used in example.

The materials needed for a sidewalk 6 feet wide, 100 feet long, and 4 inches thick will be calculated.

$\frac{6' \times 100' \times 4''}{12}$ = 6' x 100' x 1/3' = 200 cubic feet of area or volume

Raw materials required = (200 cu. ft.) $\frac{(42)}{27}$ $\frac{200 \times 42}{27}$ = 311 cu. ft. of raw materials needed

1 + 2 + 4 = volumes of mix

c s g

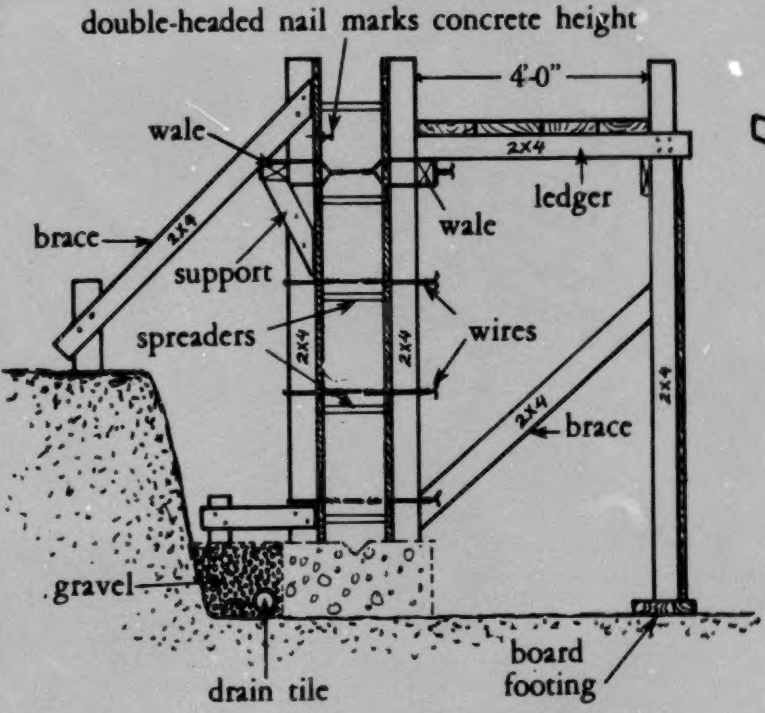
$\frac{311}{7}$ = 44.4 or 45 sacks of cement (cu. ft.)

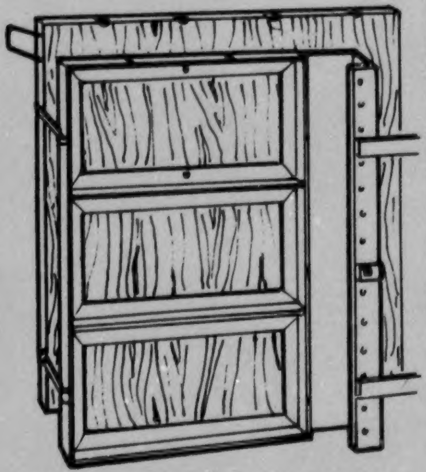
45 x 2 (twice as much sand as cement) = 90 cu. ft. of sand 90 ÷ 27 = 3.3 cu. yds. of sand

45 x 4 (four times as much gravel as cement) = 180 cu. ft. of gravel 180 ÷ 27 = 6.6 cu. yds. of gravel

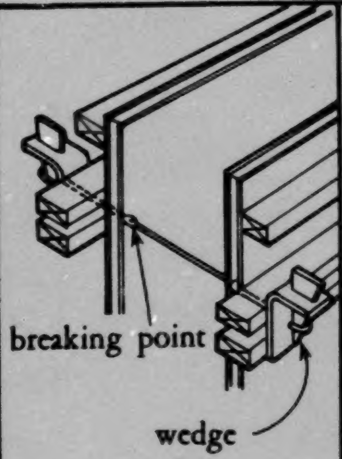
An allowance for waste is included in formula

FORMS AND TIES

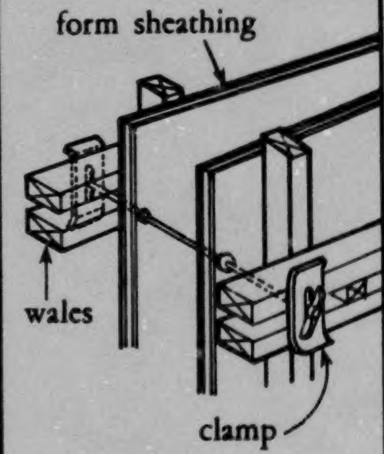

double-headed nail marks concrete height
4'0"
wale
2X4
ledger
wale
brace
2X4
support
spreaders
2X4
2X4
wires
2X4
2X4
brace
gravel
drain tile
board
footing



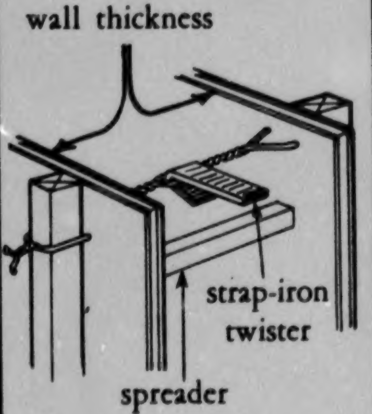
MANUFACTURED PANELS FOR FORMS


breaking point
wedge

SNAP TIE

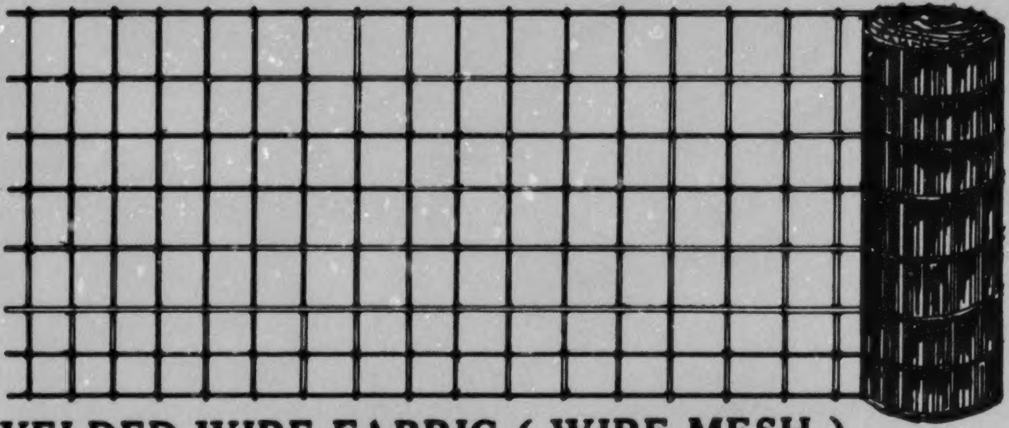

form sheathing
wales
clamp

SNAP TIE

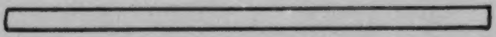

wall thickness
strap-iron
twister
spreader

WIRE TIE

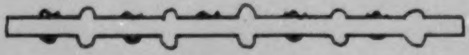
KINDS OF STEEL REINFORCEMENT



WELDED WIRE FABRIC (WIRE MESH)



SMOOTH STEEL BAR

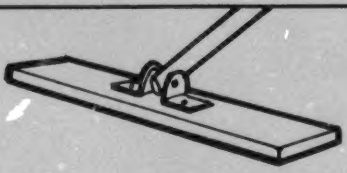
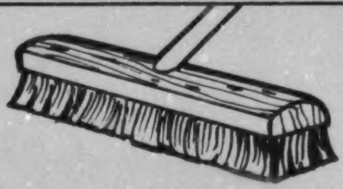
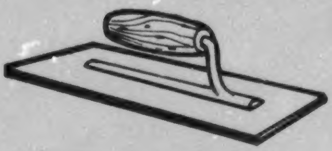
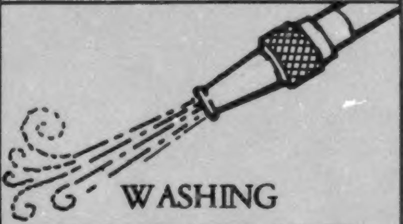


DEFORMED STEEL BAR

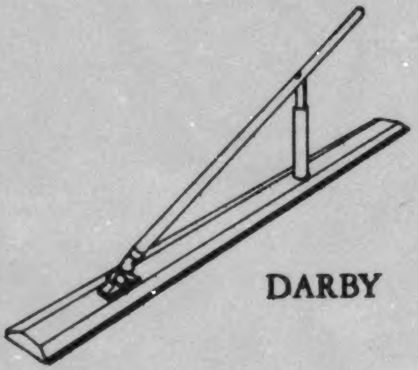
Size, Area, and Weight of Some Reinforcement Bars

Bar No.	Diameter	Bar Area sq. inches	Wt. per 100 ft.
2	1/4	0.05	17
4	1/2	0.20	67
6	3/4	0.44	150
8	1	0.79	267

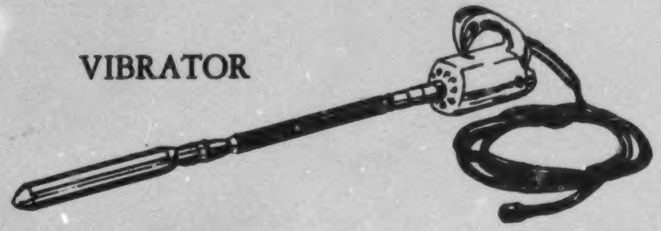
TYPES OF FINISH

SURFACE	USE	OBTAINED BY
GRITTY, NON-SLIPPING	WALKS, DAIRY BARN FLOORS, etc.	 USING WOOD FLOAT
COARSE, SCORED	DRIVEWAYS, FEEDING FLOORS, RAMPS	 USING STIFF BROOM
SMOOTH FINISH	TABLE TOPS, FEED TROUGHS	 USING STEEL TROWEL
PEA GRAIN	PORCHES, WALKS, PATIOS	 WASHING WITH WATER HOSE

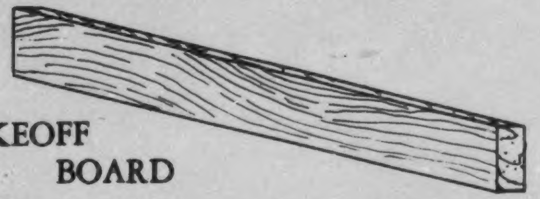
FINISHING EQUIPMENT AND TOOLS



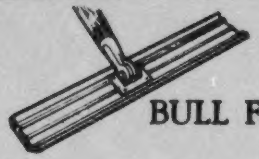
DARBY



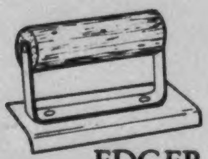
VIBRATOR



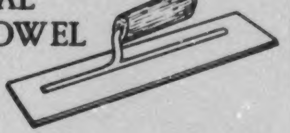
STRIKEOFF BOARD



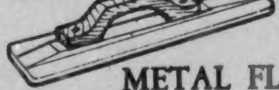
BULL FLOAT



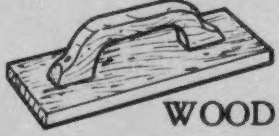
EDGER



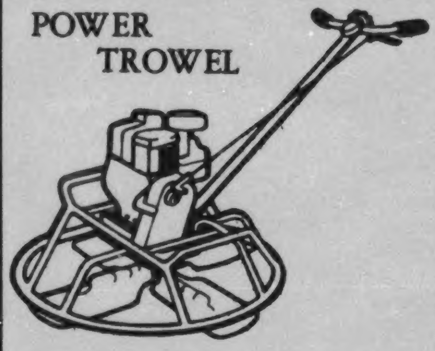
METAL TROWEL



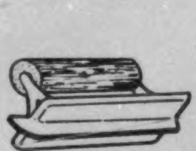
METAL FLOAT



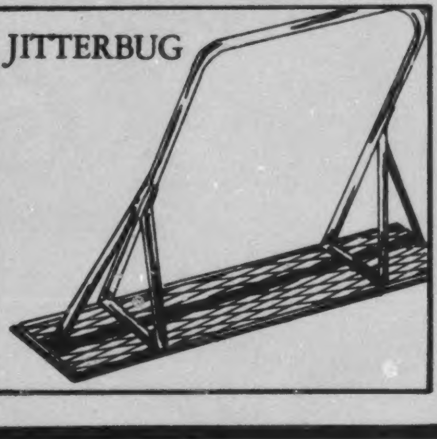
WOOD FLOAT



POWER TROWEL

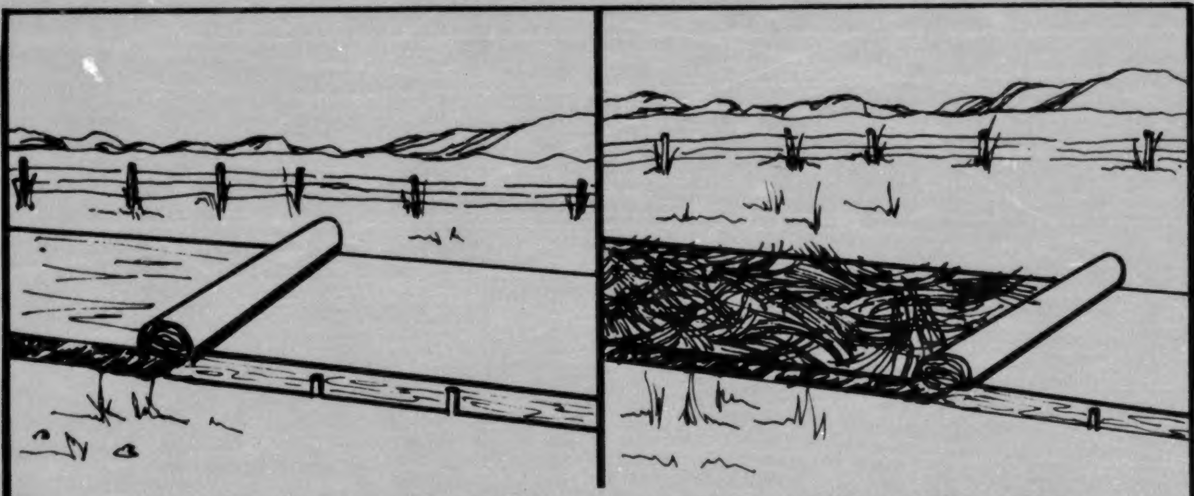


JOINTER OR GROOVER

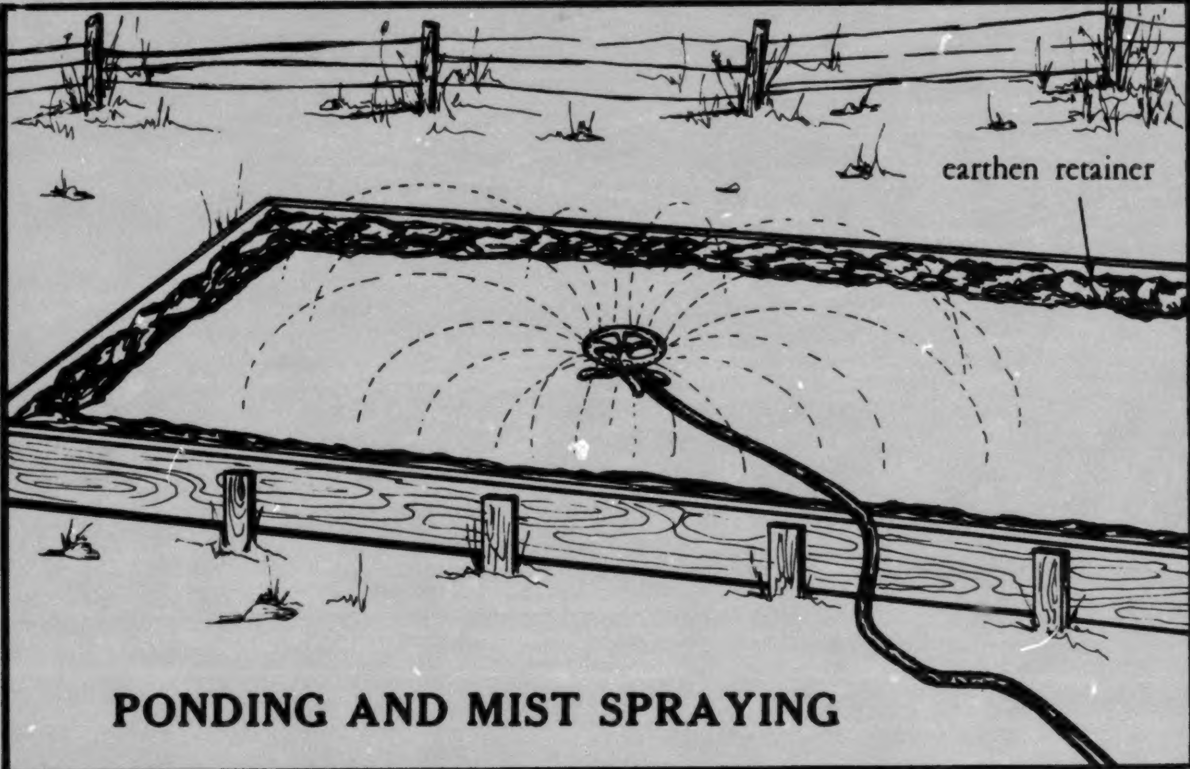


JITTERBUG

CURING CONCRETE



COVERING WITH PLASTIC AND STRAW


earthen retainer

PONDING AND MIST SPRAYING

GENERAL AGRICULTURAL MECHANICS

Unit Q: Farm Structures

Topic 4: Using Concrete Masonry, Bricks, Tile, and Stone in Farm Structures

Note: Concrete masonry is used extensively in the construction of farm structures, and many farmers with a little practice can become proficient in laying the units. Therefore, a detailed discussion is given on their use. The discussion on the use of bricks, tile, and stone is limited and of a general nature, since these are usually laid by experienced masons. Also, many of the procedures for using them are similar to those used in concrete masonry.

1. Introduction

Concrete masonry or concrete blocks are the terms applied to building units molded from concrete. The units are composed of a mixture of portland cement, water, and aggregate. The several different kinds of aggregate that may be used are sand, gravel, crushed stone, cinders, burned shale, and processed slag.

There are many reasons for the popularity of concrete masonry units in farm structures: (1) They are durable, (2) adapted to many used such as barns and storage sheds, (3) economical, (4) attractive, (5) fire proof, (6) rodent proof, and (7) easily used.

2. Concrete Masonry

Heavyweight and lightweight are the two kinds of concrete masonry units. The heavyweight units are molded from a mixture of cement, water, and normal aggregate and weigh 40 to 50 pounds per unit. This compares to 145 pounds for a cubic foot of concrete made from the same mixture. Lightweight units are made of portland cement, water, and lightweight aggregate, such as cinders, expanded clay, slag, or shale and weigh 25 to 35 pounds each. In addition to being lighter, the lightweight units have approximately 50 percent greater insulating qualities.

Transparencies Nos. 1 and 2

Concrete blocks are manufactured in 4, 6, 8, 10, and 12-inch widths and are available in many different shapes. Measurements for the units are given in nominal dimensions. The most common unit is called the stretcher block, 8" x 8" x 16". Actually, the unit measures 7 5/8" x 7 5/8" x 15 5/8". When laid in courses with a 3/8" mortar joint, it is 8 inches high and approximately 8 inches thick.

The types and actual sizes of the units in the above transparencies are given below:

a. Stretcher (3 core) 7 5/8" x 7 5/8" x 15 5/8"
b. Stretcher (2 core) 7 5/8" x 7 5/8" x 15 5/8"
c. Corner 7 5/8" x 7 5/8" x 15 5/8"
d. Joist or jamb 7 5/8 " x 7 5/8" x 15 5/8"
e. Bull nose 7 5/8" x 7 5/8" x 15 5/8"
f. Double corner or pier 7 5/8" x 7 5/8" x 15 5/8"
g. Full-cut header
h. Partition 3 5/8" x 7 5/8" x 15 5/8" or 5 5/8" x 7 5/8" x 15 5/8"
i. Beam or lintel 7 5/8" x 7 5/8" x 7 5/8" or 7 5/8" x 7 5/8" x 15 5/8"
j. Solid top 7 5/8" x 7 5/8" x 15 5/8"
k. Solid 3 5/8" x 7 5/8" x 15 5/8"
l. Sash 7 5/8" x 7 5/8" x 15 5/8"

3. Foundation and Footing

There often is some confusion as to the difference between the foundation and footing. The foundation is the part of a wall upon which the building is erected, while the footing is an enlargement at the bottom of the wall upon which the foundation rests. The footing distributes the weight of the superstructure over a greater area.

In order to have a quality structure, the foundation must be adequate and sound; and the foundation bed must be level in order for the footing and foundation to carry the weight of the structure. In areas subject to freezing, the bottom of the footing must be placed below the frost line; otherwise, there is a possibility the building will frost heave. In milder areas, the footing should be at least two feet below grade. For buildings being constructed on sloping areas, the footing should be a minimum of three feet below the lowest surface grade.

Transparency No. 3

If possible, footing should be placed on undisturbed earth. When soft spots in the earth are encountered, they should be removed and replaced with suitable materials; and the materials should be compacted. In sloping areas, the footing may be placed longitudinally to save materials and prevent excavation. The concrete for footing is placed in steps, and the footing should be all in one piece. Each step in the footing should be the same height as the masonry units to be used in the wall, and the length of the step should be divisible by eight. The trench for the bottom of the footing should be flat. Following these suggestions will prevent the cutting of the masonry units.

For buildings such as barns and sheds, the width of the footing is normally twice the width of the wall; and the depth of the footing is at least one-half its width. Some suggested footing dimensions for walls of different thicknesses are as follows:

Wall Thickness	Depth	Width
8 inches	8 inches	16 inches
10 inches	10 inches	20 inches
12 inches	12 inches	24 inches

The weight of the building and its contents are computed when designing footings for heavy buildings, and the soil on which the building is to be placed is also taken into consideration. Soft clay has a carrying capacity of one ton per square foot, while hard, dry clay can carry four tons per square foot. Gravel can carry six tons per square foot.

Forms for placing the concrete footing should be reinforced and of a dimension that will not give when concrete is placed in them. After the concrete has hardened and cured, the forms are removed. Care should be taken not to break the footing when removing the forms. The footing is cleaned of debris before laying the masonry units.

If cast-in-place concrete is used for the foundation walls rather than masonry units, the concrete for the walls is placed at the same time the footing is placed.

4. Masonry Walls

Transparency No. 4

The masonry wall, as well as the length and width of the footing and foundation, should be of a dimension that is divisible by eight. This saves time by eliminating the cutting of units and reduces the waste of materials. Also, cut blocks distract from the appearance of a structure. Only two kinds of blocks, full and half, will be needed to construct a wall with dimensions as described above.

The height of the wall is considered in determining the size of units to use. Eight or 10-inch blocks may be used in walls 35 feet high or less. Below grade walls are much stronger when constructed of 12-inch blocks.

Pilasters or columns are used to support masonry unit walls. These are used on walls of buildings that are longer than they are wide and where there are not any weight-bearing partition walls on the inside of the building. A building is normally about 2 1/2 times longer than it is wide before pilasters are used. The following provides the spacing of plasters for walls constructed of different size units:

8 inch block walls - pilasters are spaced at 12 feet intervals.
10 inch block walls - pilasters are spaced at 15 feet intervals.
12 inch block walls - pilasters are spaced at 18 feet intervals.

Transparency No. 5

Reinforcement beams used over window and door openings are called lintels. The lintels should be long enough to extend eight inches on each side of the opening and of the same thickness and width as the masonry blocks being used. For example, the dimensions of the lintel with a span of eight feet and where the wall is constructed of 8" x 8" x 16" units would be as follows: length, 9'-4"; width, 7 5/8 inches; and height, 7 5/8 inches. The width of the opening below the lintel (span) determines the number and size of reinforcement bars to use in the lintel. Steel and precast lintels are also available and may be used.

Transparency No. 6

Anchor bolts are used to fasten wooden plates to the top of the wall. The roof members are fastened to the plates. Anchor bolts 18 inches long are placed in the unit cores, and the cores are filled with concrete. A piece of wire mesh is placed on top of the second horizontal mortar joint from the top of the wall and under the cores to be filled. This keeps the concrete in the cores of the upper two blocks. Enough of the threaded end of the bolt should extend above the top of the wall to fasten the plate securely.

Flashing, made of metal or other water proof materials, is used to prevent moisture from entering masonry walls. It is used at the top and bottom of openings and on top of foundations. Bricks or other kinds of units are sometimes placed over the flashing in the bottom of windows. Concrete can also be used, but this requires the construction of forms to hold the concrete until it becomes hard. Materials often used for flashing are galvanized steel, copper, and aluminum.

Units used for partitions may be the same size as the outside wall. Smaller units, however, are often used for non-supporting partitions. Partitions and the outside walls are bonded with steel tie-rods or heavy wire mesh. The tie-rods are usually spaced about three feet apart, while the mesh is placed at every other joint. Both are placed in the outside wall as it is being constructed.

5. The Preparation and Use of Mortar

In order for a wall constructed of masonry units to have adequate strength, the mortar used must be of good quality. Factors affecting the strength of mortar are type and quantity of cementing materials, workability or plasticity of the mortar, surface texture of mortar-bedding area, water retentivity of the mortar, and quality of workmanship.

Concrete masonry walls subjected to severe frost action or severe stresses require stronger, more durable mortars. A power mixer should be used to thoroughly mix the mortar materials, and to be assured of adequate strength.

Transparency No. 7

Water is added to the mortar mixes until they become plastic. A ready mix of cement and hydrated lime is widely used to eliminate the need to stockpile these two materials.

Mortar should be used within 2 1/2 hours after mixing. If it becomes stiff on the mortar board due to evaporation, the mortar may be retempered by adding a small amount of water and remixing.

6. Laying Concrete Blocks

Masonry units should be kept dry and never wetted before they are used. Stockpiling them on pallets will free them from contact with the ground, and a covering of plastic will protect them from rain or other sources of moisture. Storing the units as close as possible to the area where they will be used will minimize their movement.

Transparency No. 8

Steps for laying masonry blocks are given below:

1. The corners are located, and the outside edge of the walls is marked with a chalk line.
2. The blocks are strung out on the first course to check the layout;
3. The blocks are removed, and a full mortar bed is spread. The mortar is furrowed with the trowel to insure plenty of mortar along the bottom edges of the blocks for the first course;
4. The corner blocks are carefully laid in position. The blocks are laid with the thicker end of the face shell up to provide a larger area to place the mortar-bedding for the next course.

5. Several (three or four) stretcher blocks are placed on their ends in order that mortar can be applied to the vertical face shells. Each block is placed in its final position and pushed downward into the mortar and against the previously laid block. The alignment and levelness of blocks should be checked often on the first course. Blocks are leveled and aligned by tapping them with a trowel;

Transparency No. 9

6. After the first course is laid, the corners of the walls are built first and are usually kept four or five courses higher than the center of the wall;

7. After the corners are laid, a heavy cord can be stretched tightly from corner to corner to serve as a guide for laying the blocks between the corner blocks. The cord is fastened to nails or wedges driven into the mortar joints so that when stretched it just touches the upper outer edge of the blocks laid in the corners. The blocks in the wall between corners are laid to slightly touch the cord in the same manner. Straight, horizontal joints are obtained by this method. As the blocks are laid, excess mortar is removed by running the trowel along the joints. The excess mortar is reworked with the mortar on the mortar board;

Transparency No. 10

8. The last unit in a course is called a closure block. Mortar is placed on all vertical edges of the closure block, and the block is lowered into place. The story or course pole, a board with markings eight inches apart, is used periodically to find the top of the masonry units for each course;
9. After the mortar has become thumb-print hard, the joints are tooled to force the mortar against the edges of the blocks, to produce uniform lines, and to make the joints moisture proof. Joints may be tooled with a 2" x 2" board, pointed end of a trowel, or 5/8 inch round rod. The 2" x 2" board and the 5/8 inch rod are 24 inches long. The rod is curved at one end. The trowel and the board produce "V" joints, and the rod produces a concave joint. After the joints are tooled, the wall is rubbed with a burlap bag to remove mortar burrs.

7. Using Control Joints to Control Stresses in Concrete Masonry

Transparency No. 11

Control or expansion joints are used in concrete masonry walls to control stresses and to prevent a slight movement of the wall from cracking the units. The location and spacing of control joints depend upon the length of the wall and points of stress. They are usually placed at junctions of bearing and non-bearing walls and at junctions of pilasters and walls. In long walls, the joints are spaced at 20 to 25 feet intervals.

The two types of control joints are the sawed and built-in. The sawed type is made with a masonry saw just after the wall is laid. A saw cut is made on both sides of the wall and opposite from each other. The depth of cut is about one-half the face shell thickness.

The built-in expansion joint may be one of several kinds. These are made by leaving a clear opening between the wall vertical section. A "Z" tiebar may or may not be used at each course. Also, several kinds of manufactured materials may be used in control joints. These are made of rubber, or a synthetic resilent material. The joint is filled with an elastic calking compound. Painting the joint with a primer coat will extend the life of the calking by preventing the masonry surface from absorbing the oil in the compound. There is a tendency for the oil in the compound to bleed through cement base paint. The application of a coat of shellac to the calking before painting will prevent this.

8. Laying a Cavity Wall

Transparency No. 12

A cavity wall is a masonry wall having two parallel wythes of masonry separated by an air space, which is usually two inches wide. This kind of wall prevents moisture from penetrating the inner wall and provides air space insulation.

Cavity wall units are laid in the same manner as a single wall, but the walls are tied together with ties. Commercial ties or No. 6 wire made into a rectangle may be used. Ties are normally spaced 16 inches vertically and 32 inches horizontally.

The cavity is protected from mortar droppings by placing a board across the opening. The board is moved and cleaned periodically. Bricks, tile, and masonry units may be also used in combination in the construction of cavity walls.

9. Veneered Walls

It is a common practice to construct the walls or building with brick, stone, tile, and concrete masonry veneer. Walls of this type have the veneer on the outside and a wooden frame on the inside. Some type of sheathing is placed over the wooden frame and next to the veneer.

Transparency No. 13

The brick, stone, tile, or masonry units are tied to the wooden frame with ties, which are spaced about two feet apart.

10. Brick, Tile, and Stone Walls

Bricks - About the same procedure used for laying concrete masonry units is used for laying bricks, tile, and stones; however, there is some difference.

Bricks are thoroughly wetted before being laid. This causes the bricks to tend to more evenly spread the mortar, to adhere batter to the mortar, to prevent the bricks from absorbing the water in the mortar, and washes the kiln dust from the brick.

Mortar joints for brick should be even, but may be from 1/4 to 1/2 inch thick.

The dimensions of the most common types of bricks are standard, 2 2/3" x 4" x 8"; norman, 2 2/3" x 6" x 8"; Roman, 2" x 4" x 8"; and SCR, 2 2/3" x 6" x 8". The classes of brick are building, facing, and glazed facing.

Stone - This may be field or cut. Stone should be wetted and the outer surfaces allowed to dry before being laid. A full mortar bed is necessary for the proper laying of stone. Several different methods are used in tooling the mortar joints.

Structural Clay Tile - Tile is molded from surface clay, shale, fire clay, or a mixture of these materials. The laying of tile is very similar to the laying of concrete masonry units.

The size, shape, number of cells per unit, appearance, and recommended uses of tile vary considerably. The specifications for the different kinds of units also vary and depend upon their use.

The three categories of tile are common, face, and cored-shell. Several different kinds are available in each category. For example, the common units may be either scored or smooth. Scored units are used when plaster or stucco is to be applied over the tile, while the smooth units are used for walls and partitions when no other type of finish will be applied. The exposed surface of face or glazed tile is treated to improve their appearance, or to make them resistant to weather or chemicals. Cored-shell units are nearly solid and are used when added strength is needed. Some of the different kinds of tile units are shown in the following transparency.

Transparency No. 14

11. Some Masonry Tools and Cleaning and Patching Masonry Structures

Transparency No. 15

Level or Plumb Rule - These are available in either wood or metal and in lengths of 36 to 48 inches. The better quality levels have two level glasses at the center and two plumb glasses near each end.

Trowels - The most used tool in masonry work is the trowel. Attention is directed to the differences in the shapes of the trowels in the above illustration. Better quality trowels are forged from a good grade of steel and hand ground to the proper shape, taper, and balance. Trowels of different lengths and widths may be purchased.

Jointers - The mortar joints are finished with these tools. A 5/8 inch rod 24 inches long may also be used to finish the joints of concrete masonry units. Those in the illustration are made by casting or forging.

Brick Set - This is a chisel like tool used to cut brick and concrete masonry units. A brick layer's hammer is used to strike the set.

Brick Hammer - The head is square and sharp and is used for splitting brick. A cut line is made around the brick by lightly tapping the brick with the head of the hammer. After the line is completed, a heavy blow is given to the center of the brick. Practice is required to get a clean cut. The blade of the hammer is used to trim the rough areas.

Corner Blocks - These are used to hold the string in place and may be hand made or purchased.

Electric Portable Saw - Electric saws are particularly useful when a large number of units need to be cut. Stationary masonry saws are also available.

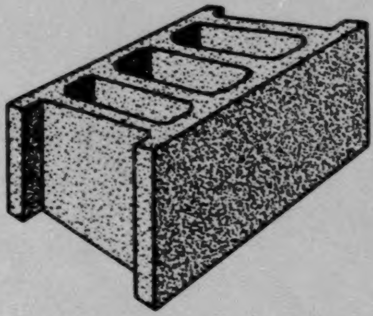
Cleaning and Patching Masonry Structures - The last step in the construction of a masonry structure is cleaning and patching. The mason should be careful not to smear or throw mortar on blocks, brick, stone or tile. Should these become smeared with mortar, they should be allowed to dry before cleaning them. A trowel and steel brush are used to remove the dried mortar.

References:

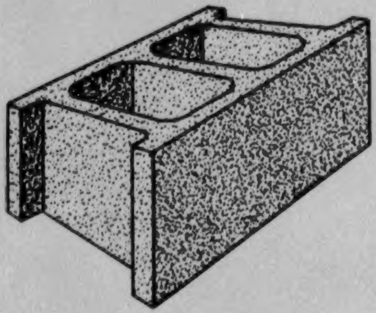
1. "Recommended Practices for Building With Concrete Masonry", Vocational Agriculture Service, University of Illinois, Urbana, Illinois, 1972

2. Dalzell, J. Ralph and Gilbert Townsend, Masonry Simplified, Vol. 1, American Technical Society, Chicago, Illinois, 1956

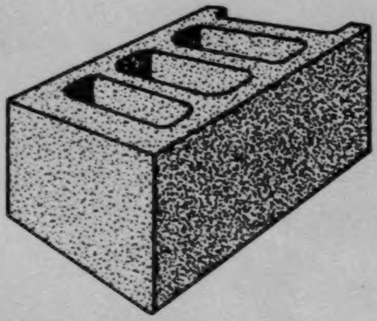
MASONRY BLOCKS



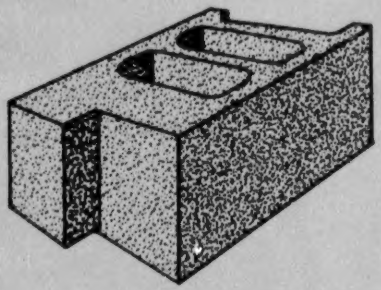
a. CORE STRETCHER



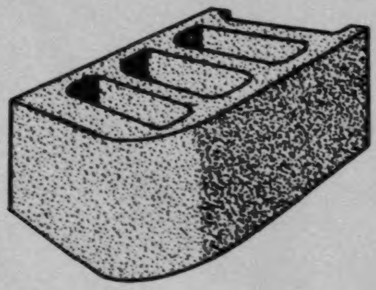
b. CORE STRETCHER



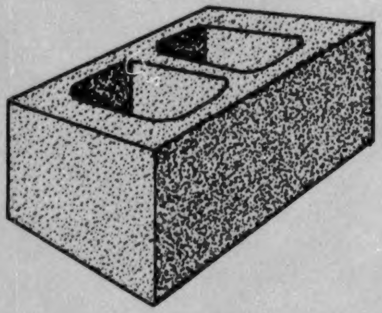
c. CORNER



d. JOIST or JAMB

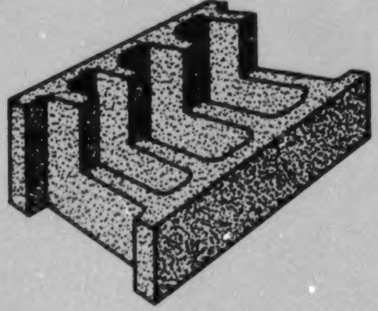


e. BULLNOSE CORNER

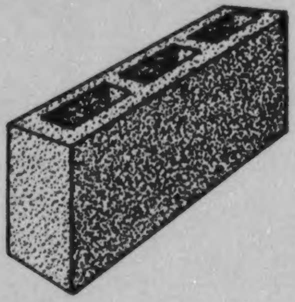


f. DOUBLE CORNER

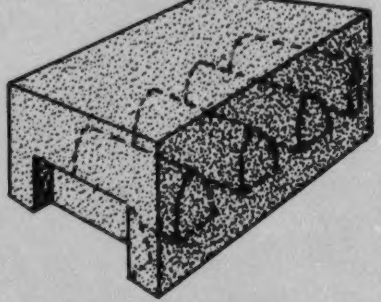
MASONRY BLOCKS



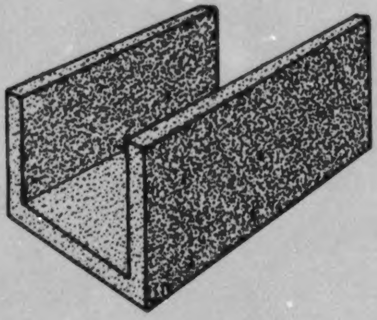
g. FULL-CUT HEADER



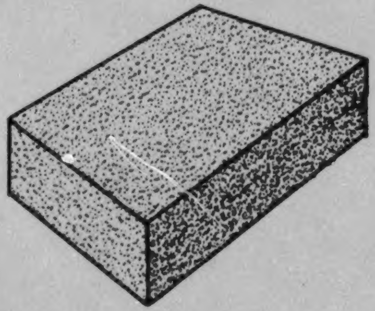
h. PARTITION



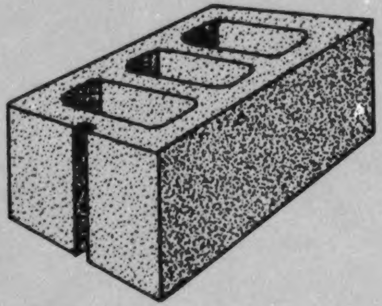
i. SOLID TOP



j. BEAM or LINTEL

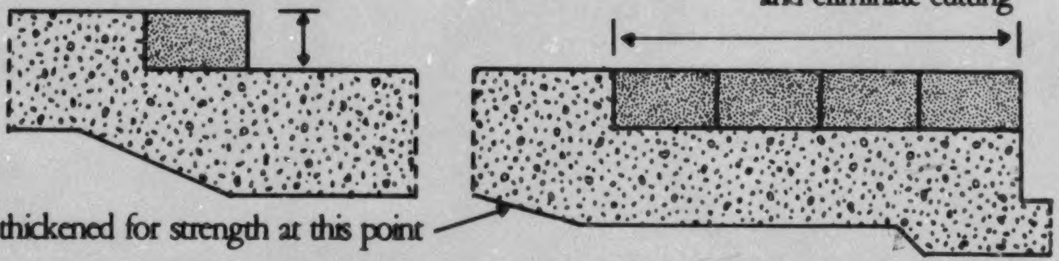


k. SOLID



l. SASH

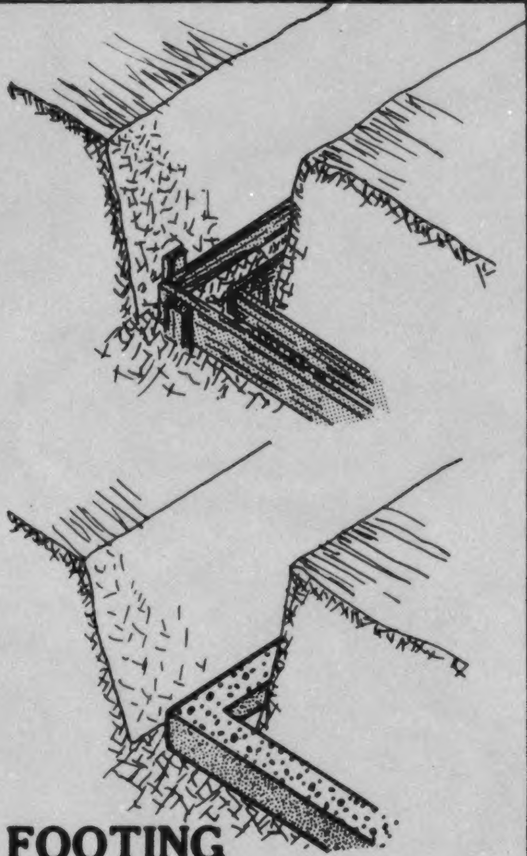
FOOTINGS
FOR MASONRY WALLS


8" high to accommodate height of concrete masonry wall

length divisible by 8" to accommodate full and half block and eliminate cutting

thickened for strength at this point

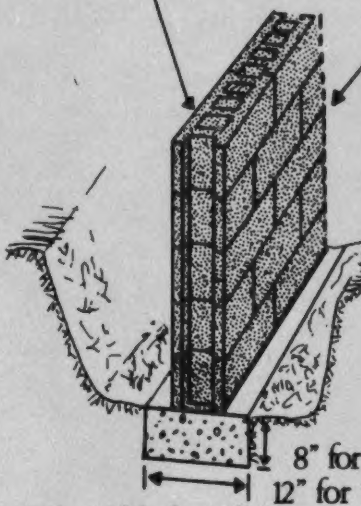
PLACING FOOTING ON UNEVEN AREAS



FOOTING TRENCH IS FLAT

8" or 12" block as needed

concrete block foundation to at least 12" above final grade

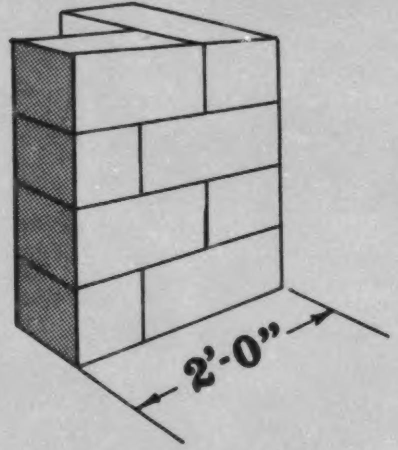

trench bottom excavated to firm soil below frost line 2'0" min.

8" for 8" block walls
12" for 12" block walls

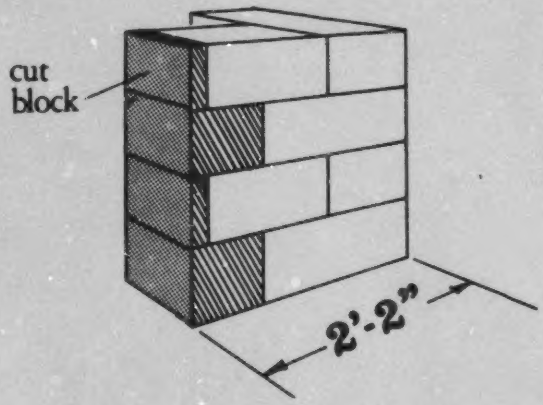
16" for 8" block walls
24" for 12 " block walls

FOOTING IS TWICE AS WIDE AS THE MASONRY

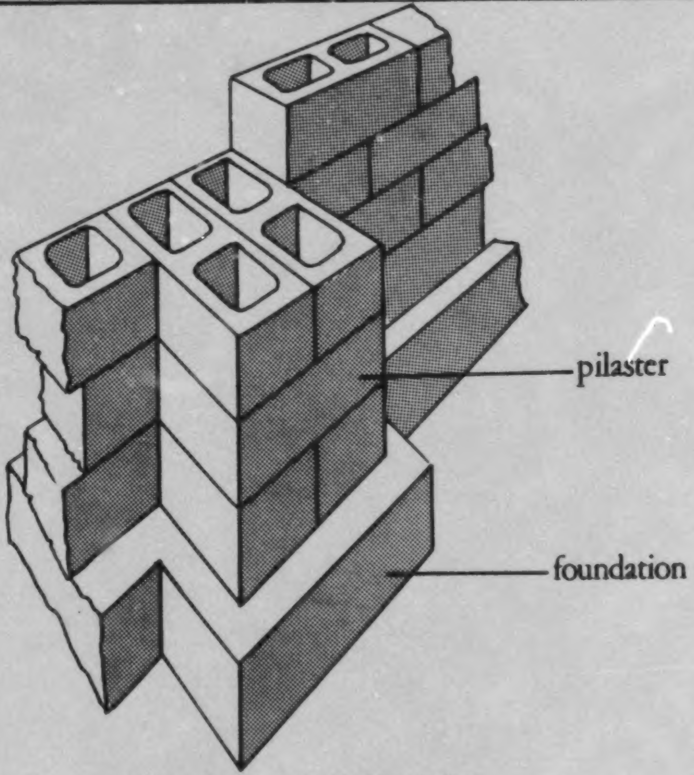
FOUNDATIONS AND WALLS



CORRECT WALL MEASUREMENT

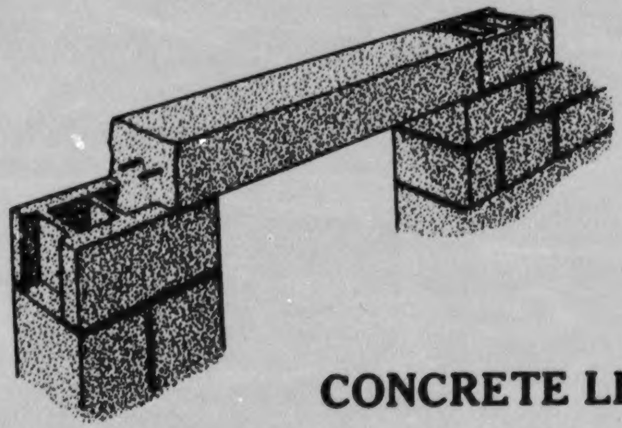

cut block
2'-2"

INCORRECT WALL MEASUREMENT

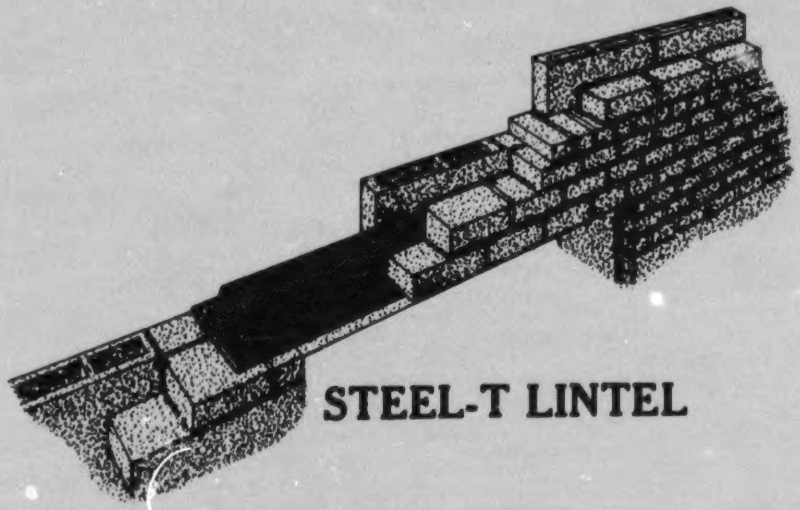

pilaster
foundation

WALL SECTION

LINTELS

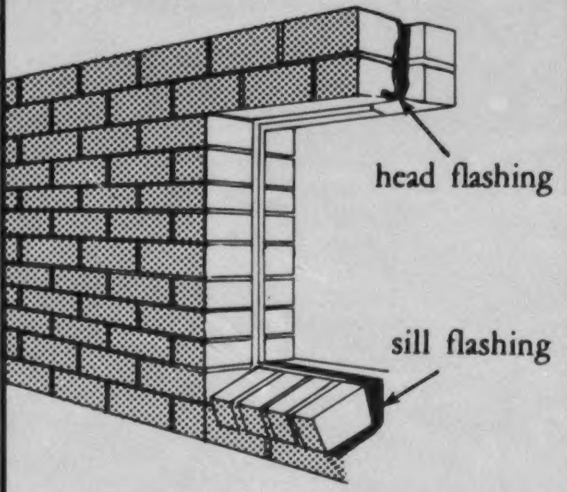


CONCRETE LINTEL

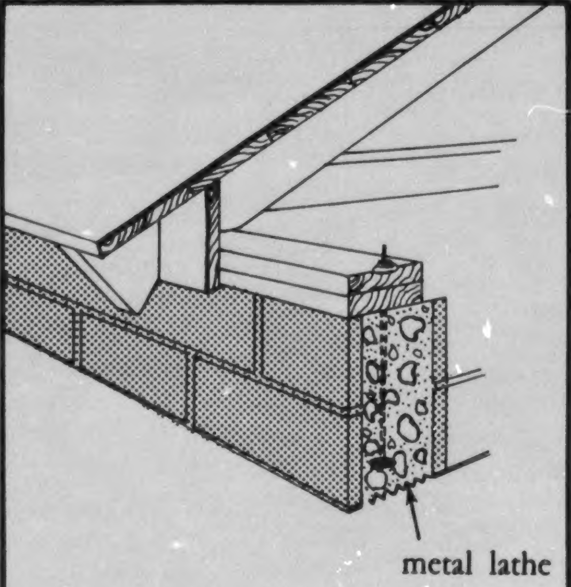


STEEL-T LINTEL

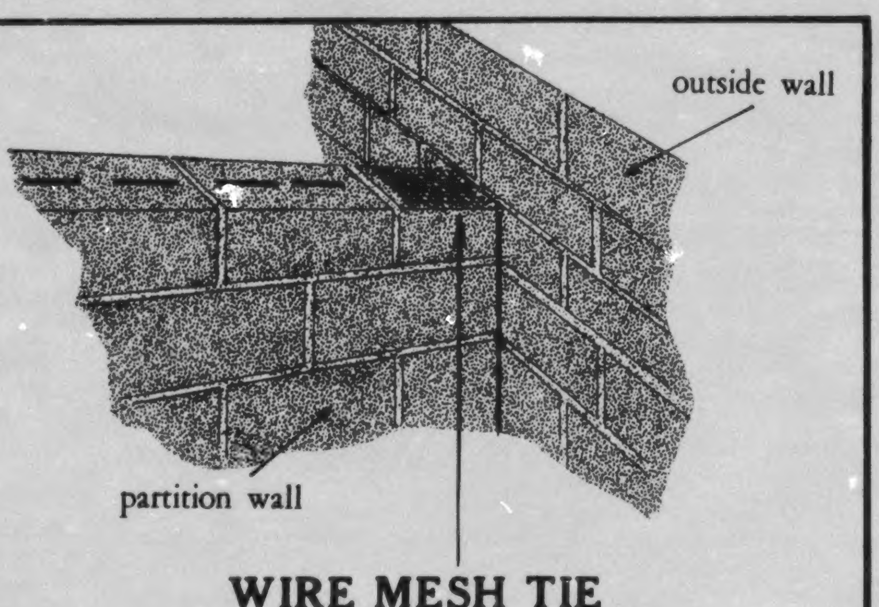
ANCHOR BOLT AND FLASHING


head flashing
sill flashing

FLASHING


metal lathe

ANCHOR BOLT


outside wall
partition wall

WIRE MESH TIE

CONCRETE MATERIALS CALCULATION

RECOMMENDED MORTAR MIXES

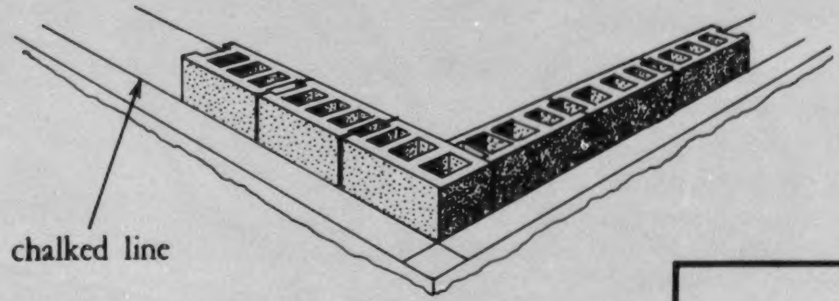
(Proportions by Volume)

Type of Service	Cement	Hydrated Lime	Mortar Sand in Damp, Loose Condition
For ordinary Service;	1-masonry cement	- - - - -	2 to 3
	or		
Walls above ground	1-portland cement	1 to 1 1/4	4 to 6
Heavy Loads, violent winds, severe frost action; Isolated piers	1-masonry cement plus 1-portland cement	- - - - -	4 to 6
	or		
	1-portland cement	0 to 1/4	2 to 3

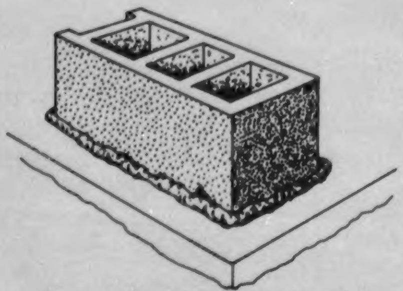
QUANTITIES OF MATERIALS FOR CONCRETE MASONRY WALLS

Size	For 100 Sq. Ft. of Wall: No. Units	For 100 Sq. Ft. of Wall: Cu. Ft. Mortar	Cu. Ft. Mortar for 100 Units
3 5/8 x 7 5/8 x 15 5/8	112.5	2.6	2.3
5 5/8 x 7 5/8 x 15 5/8	112.5	2.6	
7 5/8 x 7 5/8 x 15 5/8	112.5	2.6	
11 5/8 x 7 5/8 x 15 5/8	112.5	2.6	

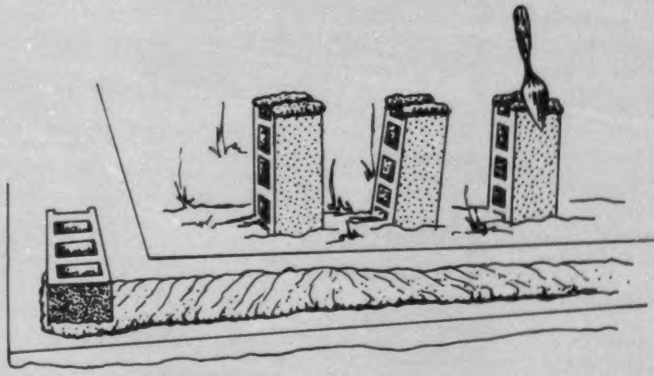
LAYING MASONRY UNITS



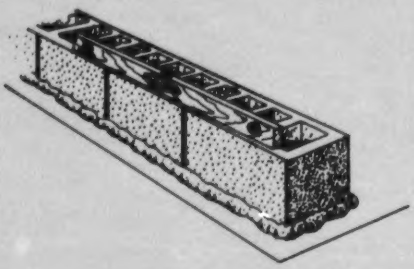
ALIGNING FIRST COURSE



LAY CORNER BLOCK

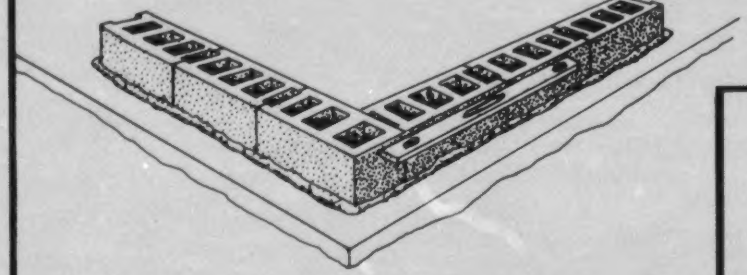


APPLY MORTAR TO FOUNDATION AND BLOCKS

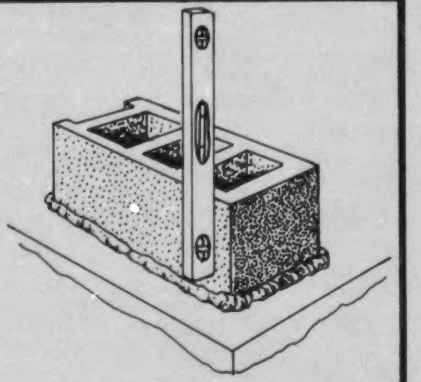


LEVEL BLOCKS

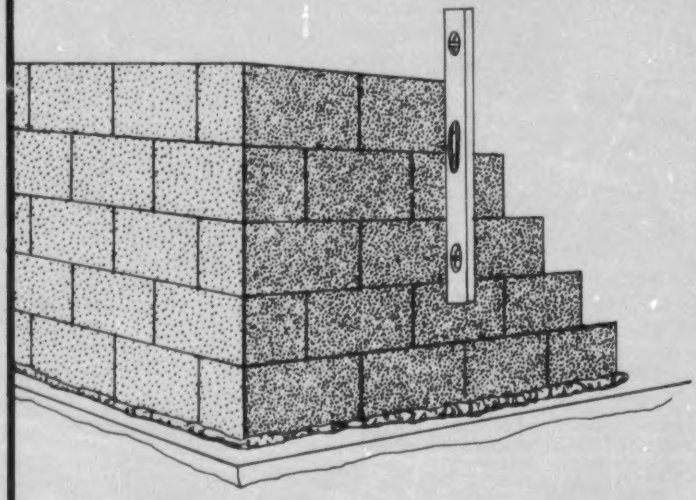
LAYING MASONRY UNITS



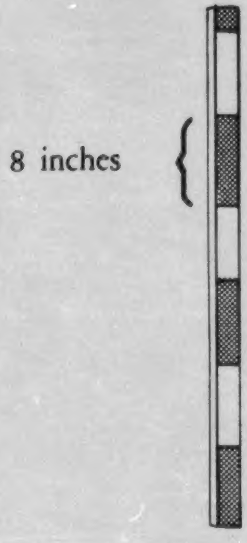
ALIGN BLOCKS WITH LEVEL



PLUMB FIRST COURSE

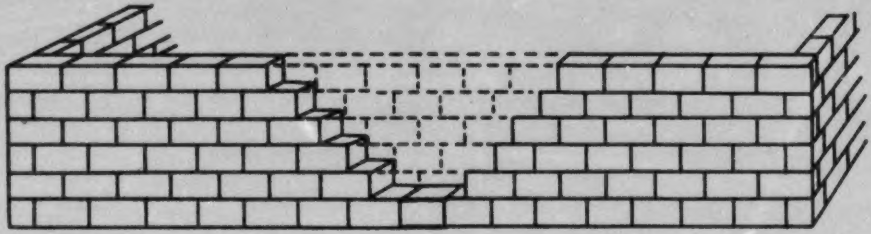


CHECK PLANE OF WALL

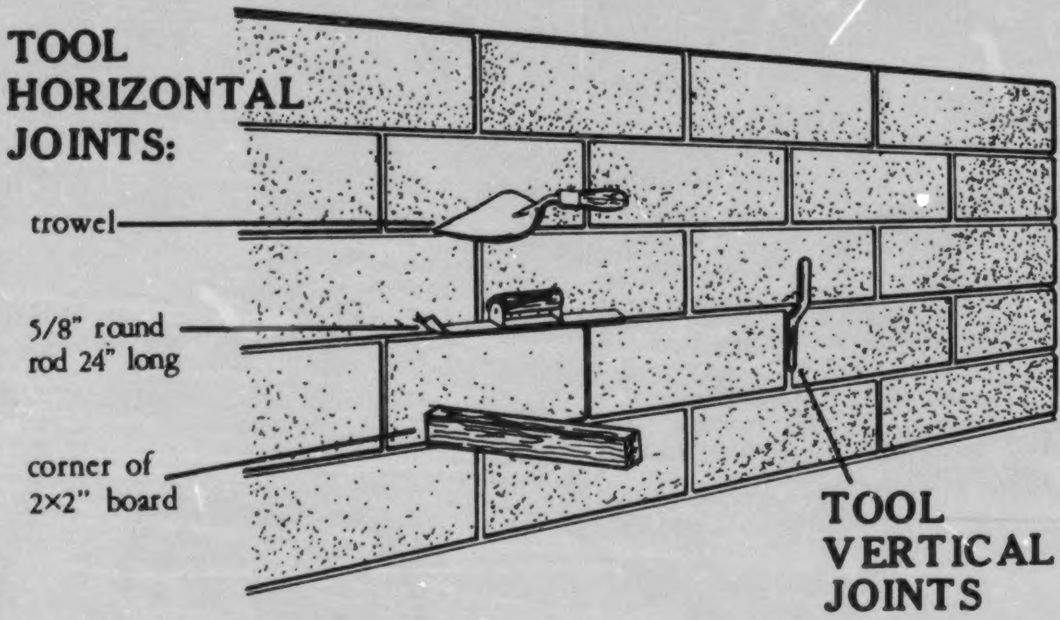


COURSE POLE

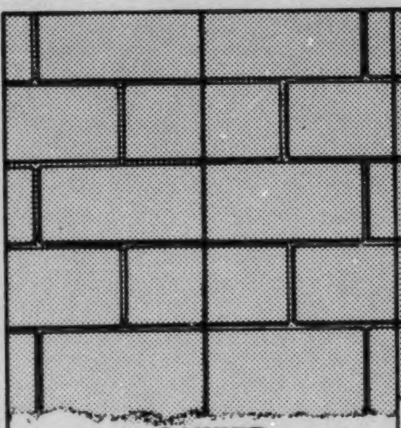
LAYING MASONRY UNITS

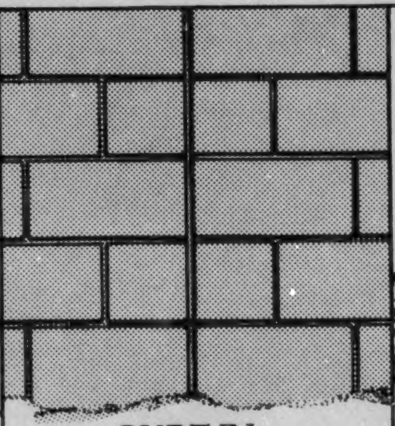


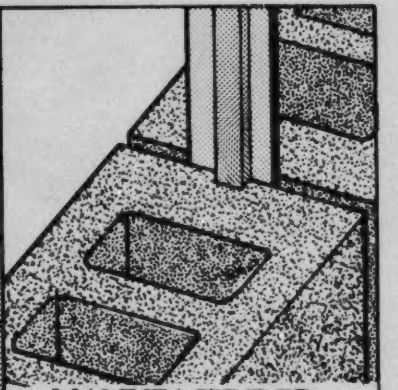
CLOSE CENTER BETWEEN CORNERS

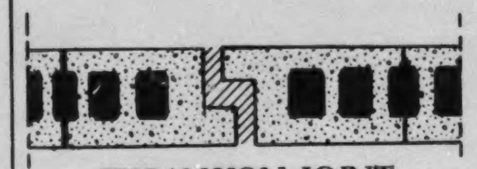

TOOL HORIZONTAL JOINTS:
trowel
5/8" round rod 24" long
corner of 2×2" board
TOOL VERTICAL JOINTS

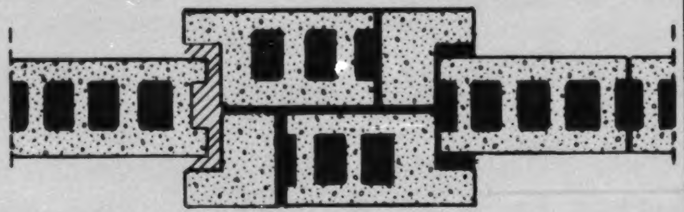
CONTROL JOINTS

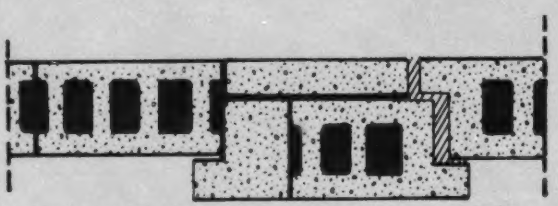

SAWED
CONTROL JOINT

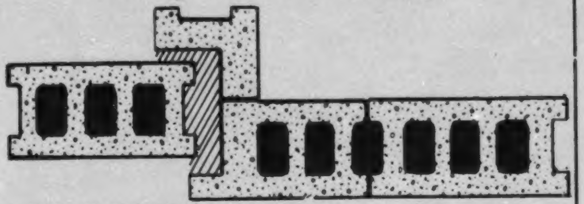

BUILT-IN
CONTROL JOINT


MANUFACTURED
MATERIAL USED IN
CONTROL JOINT

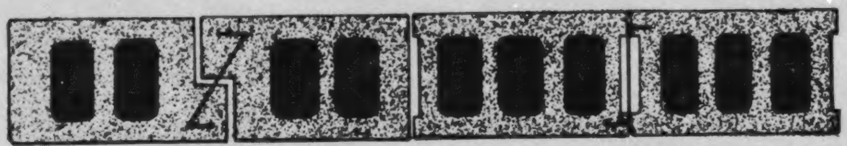

EXPANSION JOINT
IN WALL


EXPANSION JOINT AT PIER


EXPANSION JOINT AT PILASTER

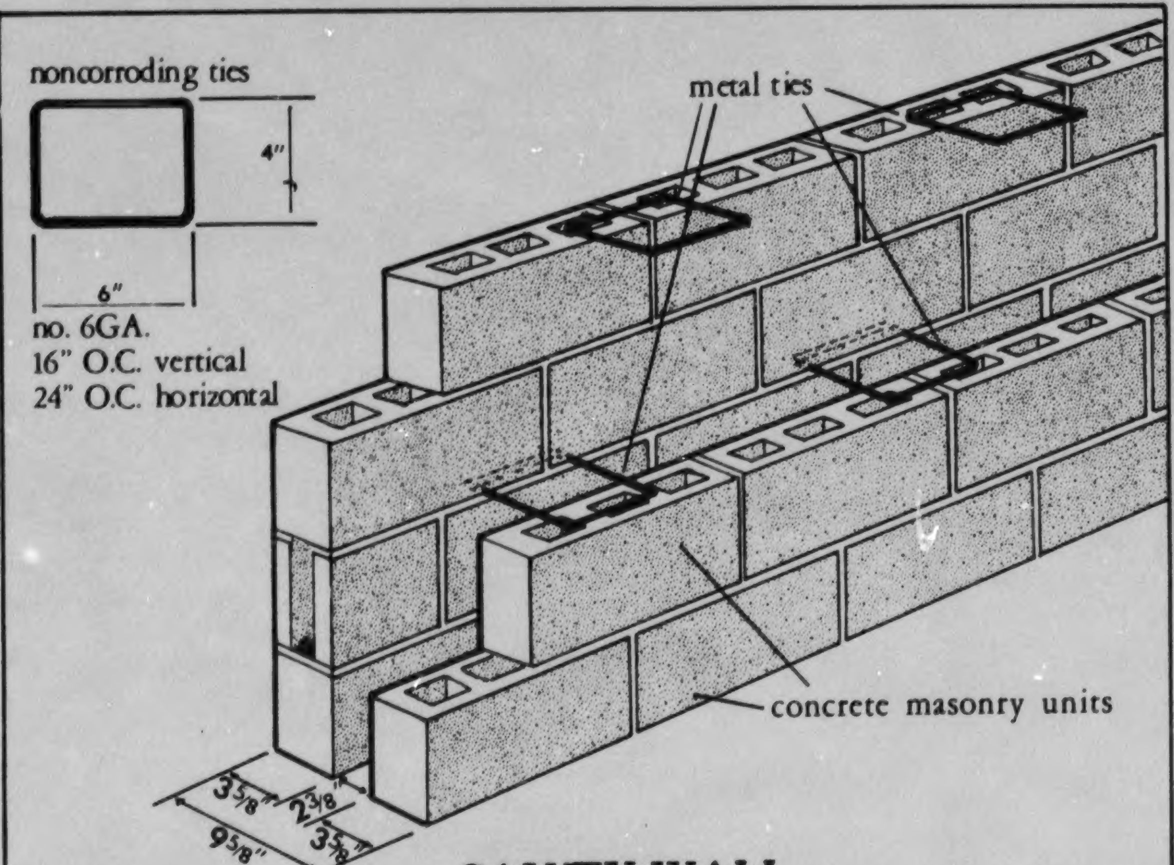

EXPANSION JOINT AT
INTERSECTING WALL

Z–TIE BARS

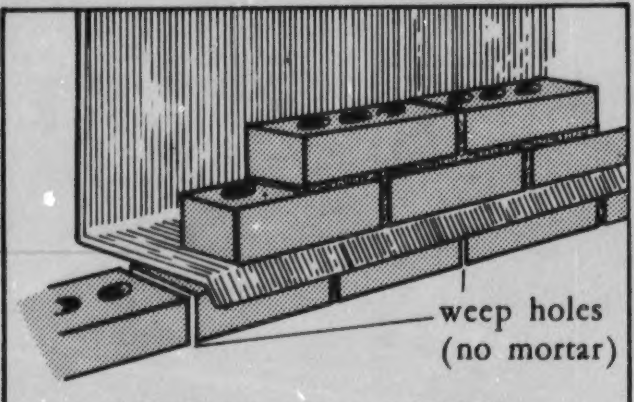

control joint using
jamb blocks

control joint using
stretcher blocks

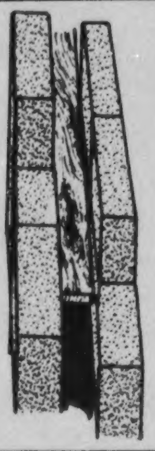
BUILDING BLOCKS


noncorroding ties
4"
6"
no. 6GA.
16" O.C. vertical
24" O.C. horizontal
metal ties
concrete masonry units
3 5/8"
2 3/8"
3 5/8"
9 5/8"

CAVITY WALL

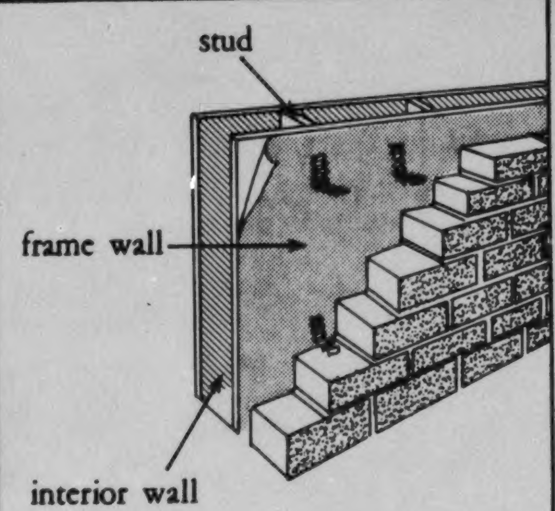

weep holes
(no mortar)

METAL FLASHING

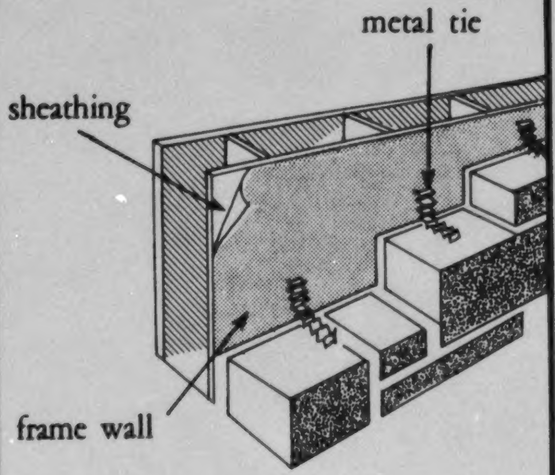


MORTAR DROPPING BOARD

TYING VENEER WALL

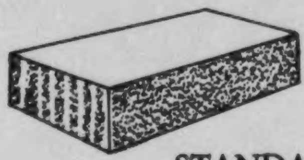

stud
frame wall
interior wall

BRICK VENEER

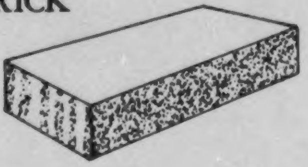

metal tie
sheathing
frame wall

ROCK VENEER

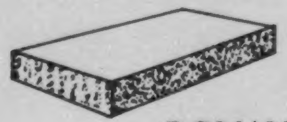
NORMAN BRICK



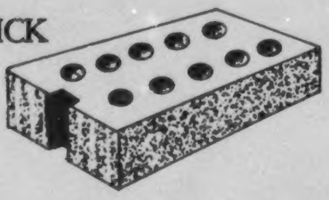
STANDARD BRICK



"SCR" BRICK

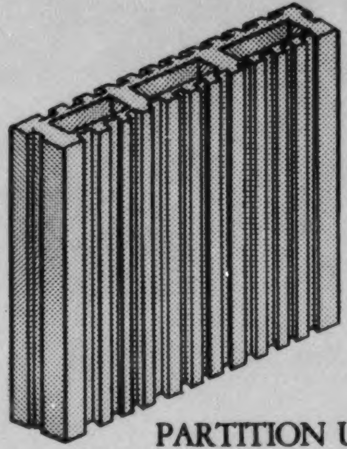


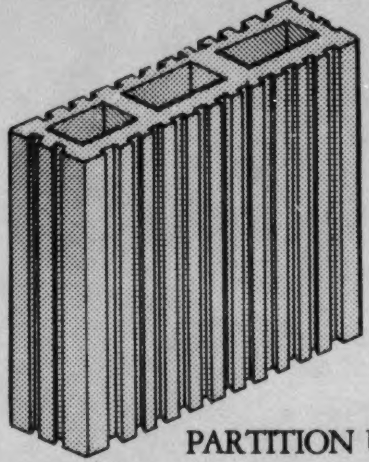
ROMAN BRICK

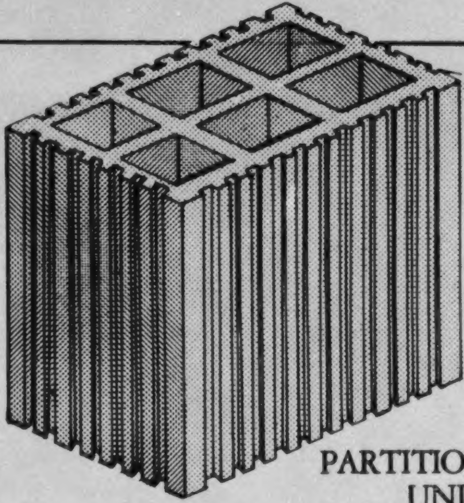


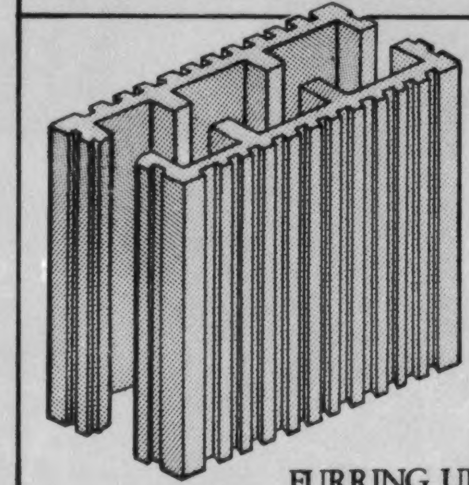
SOME TYPES OF BRICK

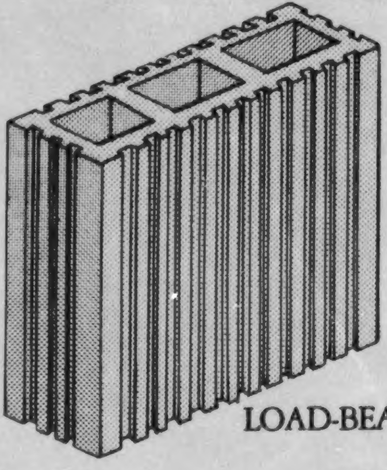
STUCTURAL CLAY TILE UNITS


PARTITION UNIT


PARTITION UNIT


PARTITION UNIT


FURRING UNIT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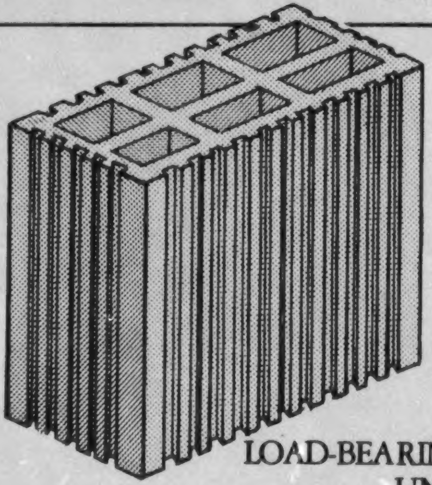
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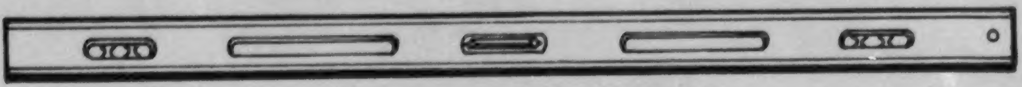
MASONRY TOOLS



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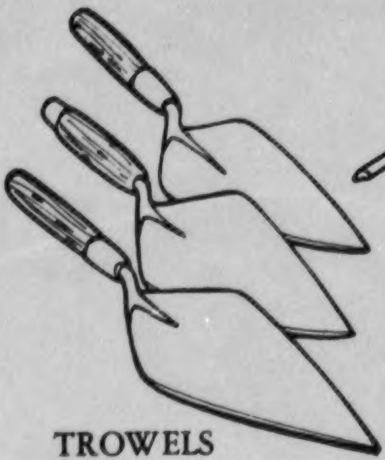

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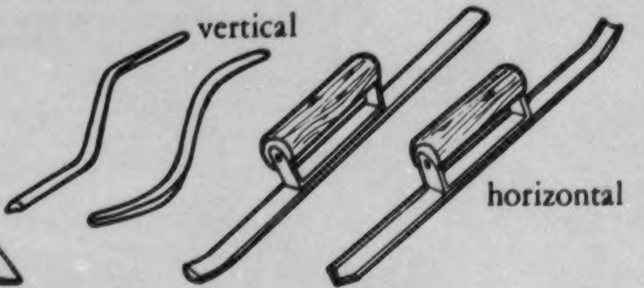
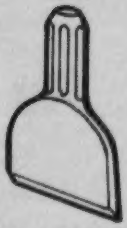

vertical
horizontal

JOINTERS



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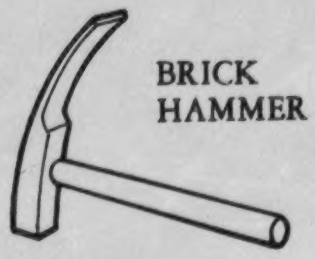

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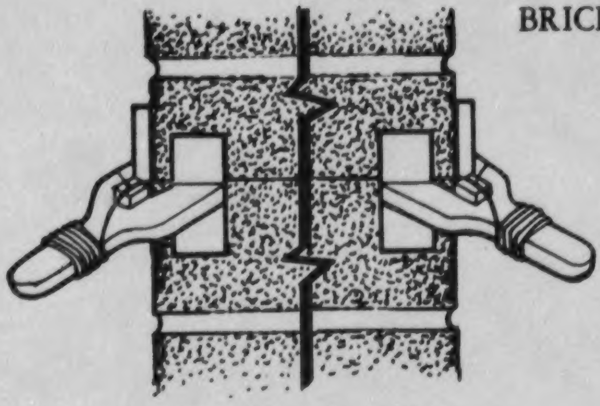
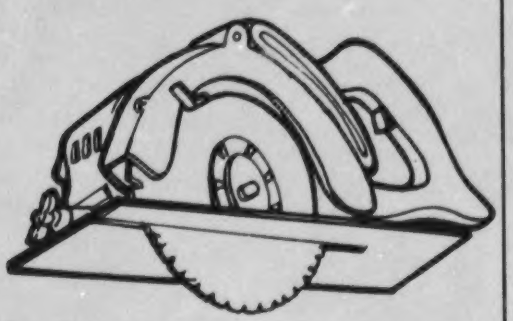


CORNER BLOCKS



ELECTRIC PORTABLE SAW

GENERAL AGRICULTURAL MECHANICS

Unit R: Farm and Ranch Electrification

Topic 1: Farm Wiring

Suggested Procedures and Activities: It is recommended that the teacher construct demonstration boards similar to the illustration in transparency No. 20 for student use in practice wiring. The dimensions for other demonstration boards that the teacher may wish to use with this topic are given in reference No. 1. Also, transparencies Nos. 4, 17, 18, and 19 could be used as demonstration boards.

1. Introduction

The use of electricity is so commonplace that most people assume that it will always be available on demand. To fully realize the dependence upon electricity, one might make a mental note of the ways in which electricity is used for only one day on the home farm. Then attempt to visualize how your life would change without this source of energy. Electricity has done more to relieve drudgery and promote enjoyable living than any other single factor.

Electricity has been defined several ways. The layman would define electricity as a source of energy that can be converted to light, heat, or power, while electrical engineers might define electricity as a movement of electrons caused by electrical pressure or voltage. The amount of energy produced would depend on the number of electrons in motion.

2. The Manufacture and Transmission of Electricity

Electricity is produced from generators that are run by water, steam, or internal combustion engines. If water is used as a source of power to turn generators, it is referred to as hydroelectric generation. There are a number of this type located in areas where huge dams have been built across large streams.

Steam is used as a source of power for generating much of today's electricity. Water is heated to a high temperature, and the steam pressure is used to turn turbines which generate electricity. This is referred to as thermal-powered generators. Fuels used to heat the water are coal, natural gas, and/or fuel oil.

Transparency No. 1

Generators at the power plant generate from 12,500 to 13,500 volts of electricity. From the power plant, electricity is carried to a step-up substation which through the use of transformers, increases the voltage from 69,000 to 500,000 volts. This increase in voltage is necessary for the efficient transmission of electricity over long distances. From the step-up substation, the electricity is carried on transmission lines to a step-down substation which reduces the voltage to approximately 7,200 volts for distribution to rural and city areas.

Transparency No. 2

Transformers located near the farm reduce the voltage to 120 or 240 volts, which is carried on cables to the meter located on the farm.

3. Common Electrical Terms

In order to acquire a knowledge of electricity and to be able to converse with those knowledgeable in the area, one must understand the meaning of the following electrical terms:

Ampere (Amp.) - A measurement in units of the rate of flow of electricity. This may be compared with the rate of flow of water in gallons per minute. Watts ÷ volts = amperes. A 60-watt incandescent lamp on a 120-V circuit would use one-half ampere of electricity.

Volt (V) - A unit of measure of electrical pressure. A given electrical pressure (V) causes a given amount of electrical current (amps.) to flow through a load of given resistance. For small appliances and lighting units, the pressure or voltage is usually 120 volts. Heating, major appliances, and motors larger than one-half horsepower are operated on a voltage pressure of 240 volts.

Watts (W) - A unit of electric power. When applied to electrical equipment, it is the rate that electrical energy is transformed into some other form of energy. The higher the wattage rating, the faster electrical energy is being converted into other forms of energy such as light. Volts x amperes = watts. Watts may be compared to the work done by water in washing a car.

Kilowatt (kw) - Equals 1,000 watts. This is a practical unit of measurement used in computing electrical energy used. Kilowatts are determined by dividing the number of watts by 1,000.

Kilowatt-hour (kwh) - A measure of electricity in terms of power in kilowatts and time in hours. A kilowatt-hour is 1,000 watts used for one hour.

Alternating Current (A.C.) - This is current that alternates or changes direction several times per second. It is fairly simple to change the direction of current because it moves in the direction the voltage forces it. Voltage can be increased or decreased with the use of a transformer.

Cycles - The flow of electricity in one direction, the reverse flow of electricity in the other direction, and the start of the flow back in the other direction. The cycles per second are regulated by the power supplier and are usually 60. Most electric clocks are built to operate on 60 cycles. More or less cycles would cause the clocks to gain or lose time.

Direct Current - Current flowing in one direction. An example would be an electrical circuit on a car.

Transformer - A device used to increase or decrease voltage.

Single-Phase - A type of electrical power, and the type most commonly available to farms. Single-phase service requires that one transformer be used between the distribution line and the meter. Usually three wires, two hot wires and a neutral wire, are installed to provide single-phase service; however, only two wires are necessary. Transparency No. 2 has an illustration of single-phase service. Both 120 and 240 volts are provided by this type of service. Single-phase service may also be supplied with three-phase service.

Three-Phase Service - Two or three transformers between the distribution line and the meter are required for this type of service. Three-phase service is not usually made available to farms with normal electrical needs. Several large motors (10 hp and larger) would justify three-phase service.

Short Circuit - A direct connection (before current flows through an appliance) between two "hot" wires, between a "hot" and neutral wire, or between a "hot" wire and ground.

Voltage Drop - A reduction in current between the power supply and the load. There will be some loss any time electricity flows through wires. Factors that may influence the amount of voltage drop are size of wire, length of wire, and number of amperes flowing. A drop in voltage may cause a loss of heat, loss of light, or loss in power output of a motor. It could cause the wire plug in a motor not protected with a time-delay fuse to burn out.

Fuse - A device used to protect wires or motors from an overload of current.

Time-Delay Fuse - A fuse with the ability to carry an overload of current for a short duration without disengaging or melting the fuse.

Horsepower (hp) - A unit of mechanical power equal to 746 watts of electrical power. One kilowatt is equal to about 1 1/3 hp.

Conductors - The wire used to carry electricity. It may be made of either copper or aluminum. The two kinds of wires should not be used together, as they are not compatible and will deteriorate readily when joined.

Insulators - Any material which will not allow electricity to pass through and is usually made of glass, bakelite, porcelain, or rubber.

"Hot" Wires - Current-carrying conductors with electrical pressure on them (usually black or red) and connected to a fuse or circuit breaker at distribution panel.

Neutral Wires - Current-carrying conductors with [illegible] pressure on them (usually white) and connected to the neutral bar at the distribution panel.

Switch - A device used to open or close a circuit.

Grounding - The connection of the neutral part of the electrical system to the earth to reduce the possibility of damage from lightning and the connection of the housing of electrical equipment to the earth to minimize the danger from electrical shock.

U.L. - Abbreviation for Underwriter's Laboratory a national organization which tests all types of wiring materials and devices to make certain that they meet minimum standards for safety and quality.

National Electric Code - A set of rules approved by the National Board of Fire Underwriters, primarily for safety in electrical wiring. All wiring should meet the requirements of the national as well as the local code.

4. Methods of Determining Electric Energy Uses

At times a farmer may wish to estimate the cost of operating electrical equipment before or after it is purchased. Usually an estimate of the number of kilowatt-hours used in a month must be determined, since electric bills are paid monthly. Three ways to determine electricity cost are discussed.

If a rough estimate of electricity cost is desired, the name plate data and estimate of operating time (wattage-and-time-estimate method) may be used. Before explaining this method, the student should understand the formulas for determining the number of watts, amperes, and volts. These are as follows:

Watts = Volts X Amperes

$$\text{Amperes} = \frac{\text{Watts}}{\text{Volts}}$$

$$\text{Volts} = \frac{\text{Watts}}{\text{Amperes}}$$

Watts X hours of operation = Watt-hours

$$\text{Kilowatt-hours (kwh)} = \frac{\text{Watt-hours}}{1{,}000}$$

Transparency No. 3a

The procedure for using the wattage-and-time-estimate is given below:

1. Wattage from name plate is determined;
2. Hours equipment will be used per month is estimated;
3. Multiply wattage by hour of operation to determine watt-hours;
4. Watt-hours are divided by 1,000 to determine kilowatt-hours used per month; and
5. Charges per kilowatt-hour are multiplied by kilowatt-hours used to get monthly cost.

The second method, counting meter disc revolutions, is explained below:

All meters have a meter constant which is designated by the letters Kh. Different meters have different constants. The meter constant in illustration is Kh = 2. Meter discs are either scored or have black marks which indicate a revolution of the disc. In each revolution of the disc in the illustration 2 watt-hours of energy are used.

1. Determine the circuit that supplies power to the equipment to be checked;
2. All other equipment or appliances on the circuit should be disconnected;
3. Meter constant is determined (shown on meter face);
4. The number of revolutions of the meter disc is counted over a timed period (since six minutes is 1/10 of an hour, this is a good period for timing equipment that operates continuously). Equipment that is off a part of the time, such as a refrigerator, should be checked through at least one "on-and-off cycle";
5. The watt-hours of energy used is determined by multiplying the meter constant by the number of revolutions of the disc during the time period;
6. The minutes in the time period are divided into 60 to determine the number of such time periods in an hour;

7. The number of watt-hours measured in step five are multiplied by the number of time periods per hour;
8. The hours of equipment used per month are determined;
9. The number of watt-hours used per month are determined by multiplying the hours of operation per month by the watt-hours used per hour.
10. The number of kilowatt-hours used per month are determined by dividing watt-hours by 1,000.
11. The cost per kilowatt-hour is multiplied by kilowatt-hours to determine monthly cost.

In the following example, the cost of energy per month for operating an electric motor used to pump water is determined. It is assumed that the motor is automatic and is part of a water-pressure system. The on-and-off cycle is six minutes, and the revolutions for a six minute period is 10. The meter constant is two.

Transparency No. 3b

The third method of determining evergy cost is the use of check meter. A meter is temporarily installed in the circuit used by a piece of equipment. It is a simple matter to determine the kilowatt-hours used by reading and denoting the meter reading when the equipment is placed in operation and reading the meter again after the operating period.

In the reading of a meter of the pointer-type, one must be aware that the pointer on each dial rotates in the opposite direction from the one next to it. Two dials read clockwise and two read counterclockwise. To correctly read the register, the direction in which eash pointer moves must be noted.

An explanation of the procedure for reading the pointer-type register is given below:

1. The number nearest pointer on right hand dial is read and recorded (9);
2. The last number passed on the dial to the left is read and recorded (8);
3. The last number passed on the third dial from the right is read and recorded (4);
4. The last number passed on the dial to the left is read (3).

The reading would be 3489 kilowatt-hours.

Another type of register found on some meters is of the odometer type. To determine the number of kilowatt-hours a piece of equipment used during a given time period, readings are taken at the beginning and end of the period; and the first reading is subtracted from the second reading.

5. Electrical Circuits

An electrical circuit is a completed path through which electricity flows. A water system and an electrical circuit are similar in many respects. Water flows through pipes and is measured in gallons per minute, while electricity flows through conductors and is measured in amperes. Other comparisons of the two systems are given below:

Water pressure (Pounds) - Electrical pressure (volts)
Rate of flow (G.P.M.) - Rate of flow (amperes)
Work done - Power (watts)

Transparency No. 4

(Note: The parallel and series circuits may be placed on a demonstration board.)

When an electrical switch is closed, the current flows through the fuse, hot wire, appliance, and back to the source on a neutral wire. Should the neutral wire fall to the ground and make contact, the current will continue to flow. If a person standing on the ground touches the neutral wire, he or she may act as the conductor and receive an electrical shock.

Two kinds of simple circuits are the series and parallel. The parallel circuit is the most commonly used in farm and home wiring. In this type of circuit, an equal amount of electrical pressure is placed on both "hot" and neutral wires; and an equal amount of current goes to each appliance or lighting unit.

About the only application for the series circuit is Christmas tree lights, and these are not as satisfactory as those wired on a parallel circuit. If a light fails to burn in the circuit, each light in the circuit must be checked, as all of the lights will fail to burn. Also, if light bulbs of different size wattage were used in the circuit, the lights with the largest wattage will not burn as bright as those having smaller wattage. This is because the smaller wattage bulb will have more pressure on it.

Transparency No. 5

The 120-and 240-volt circuits are normally used to supply power to farm equipment. The 120-volt circuit has one hot and one neutral wire with the switch and fuse installed in the hot line. The neutral wire from the equipment is connected to the neutral bar in the fuse box. For safety purposes, the neutral wire should always be unbroken and not interrupted with a switch or fuse.

The voltage on a 120-volt circuit is measured with a voltmeter. One of the leads on the voltmeter is placed on the hot terminal, and the other lead is placed on the neutral bar.

The 240-volt circuit has two hot wires and one safety-ground wire. Switches and fuses are installed in the hot lines. The two hot wires are necessary for the operation of 240-volt equipment, such as motors and welders. The safety-ground wire, connected to the case or metal frame, does not carry current unless a "short" develops in the motor or welder. If a short should occur, one of the fuses will burn-out and open the circuit.

The voltage on a 240-volt circuit is measured by fastening a lead on the volt meter to each of the hot wires. Voltage between either hot terminal and the neutral bar will be one-half of the voltage between the two hot wires. The number of amperes flowing can be measured by clamping a clamp-on ammeter around either of the hot wires.

6. Safety-Grounding of Electrical Equipment

If the metal frame of an ungrounded electrical tool or appliance comes in contact with a damaged or bare wire, a person touching the case of the appliance could receive a fatal shock. To prevent this possibility, a safety-ground wire should be attached to the appliance to carry the current from the metal case to the ground.

Transparency No. 6

An illustration of safety-grounding of equipment operating on 240-volts is shown in transparency No. 5. In the above transparency is illustrated the grounding of equipment operating on 120 volts. The safety-ground wire may be bare, but a three-wire romex is recommended. Safety-ground wire in three-wire romex is usually green in color. A current-carrying neutral should never be used for a safety-ground. Likewise, a safety-ground wire should never be used as a current-carrying hot or neutral wire.

Using grounded receptacles and a safety-ground on all circuits will allow the safety-grounding of appliances when they are plugged into the outlet. Attention is directed to the grounding of the convenience outlet in the above transparency,

An adapter must be used to properly ground appliances connected to receptacles not safety-grounded. If an adapter is used, the green pigtail wire must be connected to the ground to give protection from electrical shock should a short occur.

A test lamp (light bulb in pigtail socket with two leads) may be used with the demonstration board, shown in transparency No. 4, to demonstrate a completed circuit. One lead is placed on the hot wire at the switch, and the other lead is placed on the ground at the light fixture. The test lamp may also be used to demonstrate the testing of appliance frames for shorts. One lead is placed on a ground (water or gas line), while the other lead is placed against the frame of the appliance. If the light burns, a short exists. Should there be a short, the appliance should be unplugged and repaired.

7. Electrical Circuit Protection

Electrical circuits should be protected from an overload of amperes. Too many amperes flowing through an unprotected circuit will generate heat, which may deteriorate or melt the insulation and possibly cause a fire. The number of amperes that a given conductor can carry safely depends upon the kind and size of wire, type of insulation, length of run in feet, and type of installation. Allowable current-carrying capacities of various conductors may be found in the following chart. Other charts giving the proper size conductors to use for different lengths of run are provided in the topic on "Kind, Selection, and Maintenance of Electric Motors."

Chart No. 1

Types of Circuit Protection

Transparencies Nos. 7, 8, and 9

The four types of circuit protection are common fuses, fusetrons, fustats (two parts), and circuit breakers. Fuses are of two basic types, plug and cartridge.

Standard fuses contain a link made from a low melting alloy which is designed to carry currents up to the rating of the fuse. Current higher than the ampere rating causes the link to heat above its melting point. When the fuse "blows", the link melts and opens the circuit.

Time-delay fuses (fusetrons) are made to carry a temporary overload, such as the overload caused by the starting of an electric motor. The fuse, however, still provides protection for the circuit, and a short circuit will melt the fuse link. Using the same size of common fuse will cause the fuse link to melt every time an electric motor starts. The use of a larger ampere common fuse will not provide protection for the motor or circuit.

Fustats, nontamperable fuses of the time-delay type, have a different size base and require a special adapter that is screwed into the standard fuse socket. After the adapter has been installed, it cannot be removed. For example, the installation of a 15-amperes adapter allows the use of only 15-amperes or smaller fuses.

Transparency No. 10

Since the use of breakers eliminates the replacement of fuses, they are being widely used on farms, even though the circuit breaker box costs more than a fuse box. Circuit breakers are of two types, thermal and magnetic. The thermal breaker has two contacts held together by a bimetal latch. An overload of current causes the bimetal strip to become heated, the latch releases, and the points spring open. After the bimetal strip cools, the toggle is reset; and service is restored.

The magnetic breaker has contacts that are held together by a latch which is released by the action of an electromagnet. The amount of current flowing through the circuit will determine the size of the electromagnet. This type of breaker is reset by moving the toggle to the "on" position.

8. Common Wiring Materials

Transparency No. 11

Wire Sizes

The size of conductor used for wiring is very important. A larger wire will safely carry more voltage, just as a larger pipe will carry more water than a smaller one with a given pressure. An attempt to force too much current over a small wire will increase the resistance and reduce the voltage, and the electrical devices will not function properly.

Electrical wires are numbered to indicate their size (gauge) according to the American Wire Gauge Standards. Small numbers indicate large wires, while large numbers indicate small wires.

There are two kinds of wire, solid and stranded. Stranded wire is made up of several small wires wrapped together. This provides more flexibility for the wire, particularly the larger sizes. Indoor wire larger than a No. 8 is generally stranded. A No. 6 stranded conductor is made up of seven smaller wires whose total cross-sectional area is the same as that of a No. 6 solid conductor.

Types of Wire - Outdoor wire is used for wiring between buildings and may be either copper or aluminum. Aluminum wire is lighter in weight and less expensive; however, one size larger wire is required to carry the same load in amperes as copper. Outdoor conductors are usually covered with neoprene or polyethylene.

The use of three-conductor self-supporting service drop wire has become common. It consists of two insulated wires wrapped around a bare stranded wire which is used as the ground and supporting wire.

The use of underground wire has increased in the last few years. These eliminate damage to the wire from ice storms and wind. The elimination of overhead wires also adds to the attractiveness of the farm.

Indoor wiring is designed for use inside buildings; however, some types can be used both inside and outside. Special coatings have been developed for areas inside buildings having excessive moisture. Most of the insulations used on inside conductors are made of fire and moisture resistant materials.

Transparencies Nos. 12a and 12b

Conduit - Where wires require mechanical protection, conduit should be used. Other advantages of using conduit are a greater choice of wire colors, the use of additional conductors, and added safety if the conduit is properly grounded.

Both flexible and nonflexible conduit are available. There are two kinds of nonflexible conduit, rigid and thin wall. Rigid has threaded ends and is much thicker. Thin wall is most often used for farm wiring. It is available in 10-foot lengths, is easily bent, and is mounted to steel boxes. Metal straps are used to support and keep it in place, and metal connectors and screw locks are used to fasten it to the boxes. The thin wall conduit may be cut with a 32-tooth hacksaw. A reamer or file is used to remove the rough edges on the inside of the conduit.

Care should be taken not to injure or reduce the size of the internal diameter when bending conduit. The conduit must be mounted before the wires are "fished" through it.

Outlet and Switch Boxes - These are installed at every switch, light, or junction point where wires are attached, with the exception of some outside wiring. Outlet boxes are usually octagonal or square. Switch boxes are made for flush or surface mountings.

Both octagon and square boxes are about the same size and measure four inches in diameter and 1 1/2 inches deep.

Flush mounted switch boxes are used in walls when the wire is concealed. Several types and depths of these boxes are available. The most commonly used box has beveled corners with clamps for nonmetallic cable. The sides are removable in order that more than one box can be ganged together to provide for a series of switches or receptacles at one location.

Surface - mounted switch boxes are made to fasten to an exposed surface. They receive wide use in barns and other outbuildings. Their corners are round but do not have clamps for nonmetallic cable. They can be used for conduit or cable wiring; but if nonmetallic cables are used, they should be the type that has a bare ground wire, which is used to ground the boxes.

To prevent possible damage to the wires, the number of wires of various sizes that may be permitted in boxes is specified by the code. The table below provides the number allowed for boxes of different sizes:

MAXIMUM NUMBER OF CONDUCTORS PERMITTED IN OUTLET, SWITCH AND JUNCTION BOXES[1]

Trade Size of Box	Maximum Number of Conductors No. 14	No. 12	No. 10	No. 8
4" octagon box, 1 1/2" deep	8	7	6	5
4" square box, 1 1/2" deep	11	9	7	5
Switch or handy box, 2" deep	5	4	4	
Switch or handy box, 2 1/2" deep	6	6	5	
Switch or handy box, 3" deep	7	7	6	

[1] These numbers of wires apply if no cable clamps, fixture studs, switches, or receptacles are contained in the box. If the box contains cable clamps or fixture studs, the number of wires shall be reduced by one, with a further reduction of one wire if flush switches or receptacles are contained in the box. Each wire running through the box without splice is counted as one. Each wire terminating in the box is counted as one.

Receptacles - Several different types of receptacles are available. The ones shown in the transparency, as can be observed, are of the porcelain type.

Switches - Several kinds of switches are available. Three types are the single-pole, three-way, and four-way. These differ in number of terminals and in the number of places from which they can control lights.

Single-pole switches have two terminal screws and control lights in one location. Three-way switches have three terminals and control lights from two locations. Four-way switches have four terminals and are used in combination with three-way switches to control lights from three or more locations.

Duplex Receptacles - These are used to connect electrical equipment and appliances to a circuit. Receptacles for both 120-and 240-volt circuits, as well as the grounded type 120-volt, are available.

Blank Covers for Boxes - Blank covers are used to cover surface mounted boxes. Switch box covers are also available.

Wall Plates - Switches, duplex receptacles, and combination plates are available in bakelite, metal, glass, and other materials. Also, these are available in several different colors.

Connectors - Cables are fastened to boxes that do not have built-in cable clamps with cable connectors. These are available that will fit different sizes of knockouts in boxes.

The pressure-type split-bolt connector is used to connect outside wires to entrance wires.

Several kinds of solderless connectors are available. These are used to join wires inside junction boxes. One kind has a coil spring thread inside the cap which is turned onto the pigtail connection to make and insulate it in one operation.

Ground Clamps - Two types of ground clamps are shown in the transparency. One is used to ground the electrical system to a ground rod, which is a copper rod 5/8 inches in diameter and about eight feet long. The other is for grounding the system to deeply buried water pipes.

Straps and Staples - These are used to fasten conduit and cables to the surfaces over which they run. There are numerous types available.

Insulators - Outdoor wires are supported by insulators. The racks are normally used for long spans, while screw knobs are placed in areas having a moderate amount of tension.

Entrance Elbow or Sill Plate - Either one of these may be used where conduit or entrance cable enters the building. A removable cover on the elbow aids in installing the wires. The sill plate fits around the entrance cable where it enters the building.

9. The Wiring System

Any well-planned wiring system must be safe, economical, adequate, and expandable. Conductors used in the system should be of a size that will carry the necessary amperage safely. They must be fused properly and installed according to the National Electric Code. Safety is acquired when the code is followed. The other factors depend upon careful planning.

An economical system is one that is safe, adequate, and efficient and was acquired at a minimum cost.

For a system to be adequate, it should have sufficient voltage to operate all appliances with no more than a two percent voltage drop for lighting and heating appliances. There should be no more than a three percent voltage drop for motors. An adequate number of outlets and switches of the proper type and rating should be included in the system. Also, anticipated future electrical needs should be considered and allowances made for their installation.

10. Common Splices and Connections

Improper splices and connections may not provide dependable electrical service and can be a very serious fire hazard or life safety factor. The three basic splices are the western union, center tap, and rat tail.

Transparencies Nos. 13a and 13b

Western Union - This splice is used when strength is required in the splice, such as running a wire from one building to another. Enough insulation is removed from the wires to be spliced to allow five or six turns of the wire. If the insulation is removed with a knife, it is cut at a slant to prevent the cutting of the wire, which could reduce its strength. Combination wire cutters and strippers are available. These are adjustable and can be used on a number of different wire gauges without damage to the wire. To begin the splice, each of the wires is bent into a 90-degree angle about one inch from the insulation. The wires are crossed and one wire is wrapped around the other wire. Pliers may be used to smooth the sharp edges. The splice is now ready for soldering and taping, which will be discussed later.

Center Tap - The tap splice is used to branch off of a wire and go in another direction. Since this splice has very little strength, an insulation should be used to anchor the wire. About two to 2 1/2 inches of insulation is removed from the main wire. The tap wire is bent into a 90-degree angle about one inch from the insulation on the center tap. The tap wire is placed in the center of the main wire and seven or eight wraps are made around the main wire.

Rat Tail Splice - This type is used in junction boxes where the conductors are clamped in the box. This splice has very little strength.

Attention is called to the proper connecting of conductors to terminals. The loop should be attached to the terminal in the direction in which the screw turns.

Transparency No. 14

Soldering Splices - To solder the western union splice, the wires are first coated with an electric soldering paste. If rosin core solder is used, it may not be necessary to use a soldering paste. The heated soldering iron is held on the underside and against the wire until the wire will melt the solder. Solder is flowed into every crevice in the wire.

The center tap and rat tail splices may be soldered in the same manner as the western union splice. Another method of soldering the rat tail splice is to dip it into a ladle filled with molten solder.

Applying Tape - At one time, two kinds of tape were used for taping splices. The splice was taped first with a rubber tape and then friction tape was used to cover the rubber tape. The plastic tape available today is the only tape needed. It is faster, neater, cleaner, and is water-and acid-proof.

To start a splice, the tape is extended about 3/4 of an inch over the insulation on one end. Each lap is extended one-half the distance of the previous wrap. The tape is kept tight as each wrap is made and is wrapped about 3/4 of an inch over the insulation on the opposite end. Two complete wrappings over the splice result in four thicknesses of tape. Two wraps are usually sufficient for proper insulation.

Transparency No. 15

Solderless Connectors - These may be used instead of soldering and taping. Size of wire, type of wire, and location of connection will influence the connector to use for a specific job.

11. Types of Switches

Transparency No. 16

Simple Switches - A simple (single pole-single throw) controls a circuit from one location. Toggle, mercury, silent, rocker button, and push button are the types available. The thermostat and humidistat are two types of single pole switches operated by mercury. A single pole switch has two terminals (screws) and two positions, open and closed. Switches are never installed in a neutral line.

Transparency No. 17

The wiring diagram illustrates how a single pole-single throw switch is connected in a circuit to control a light. With the switch in the fuse box in the closed position, the flow of current can be traced to the switch, through the switch when switch is closed, through the light, and back to the source on the neutral wire.

Transparency No. 18

Three-Way Switches - A three-way switch is referred to as a single pole - double throw switch, and is used to control a circuit from two locations. Three-way switches have three terminals (screws). The single terminal on the side of the switch is called the common terminal, while the two terminals on the opposite side are called traveler terminals.

The operating principles and wiring diagram of three-way switches are illustrated in the above transparency. To install two three-way switches, the hot wire from the power source is connected to the common terminal of one of the switches. Each of the traveler terminals of one switch is wired to the traveler terminals of the other switch. The common terminal of the remaining switch is connected to the hot lead of the light. The neutral lead on the light is connected to the neutral wire.

The current flow can be traced from the hot wire and through the circuit to show that either switch will turn the light on or off.

Transparency No. 19

Four-Way Switches - These are used between three-way switches to provide additional points of control for a circuit. They are wired to the two traveler wires of the three-way switches.

The wiring diagram illustrates the operating principle of a four-way switch and the connections that are made. The traveler wires between the two three-way switches are cut and attached to the terminals of the four-way switch and are wired to feed straight through the four-way switch.

The current flow can be traced from the hot wire source and through the circuit to show that either switch will turn the light on or off. The two positions of the four-way switch will feed straight through or diagonally.

12. Installing Lighting and Outlet Circuits

The wiring diagrams that have been used to illustrate the various connections have not shown the wiring, boxes, outlets, and controls as they must be actually installed. It is important that each student have an opportunity to practice the installing of lighting and outlet circuits.

Transparencies Nos. 20 and 21

The wiring demonstration board may be used to provide student practice. All connections and splices should be made in boxes. The wire used and all installations should be the same as would be used and made in a building.

No. 14 romex with ground wire should be used for the outlet circuit. No. 14 three-wire romex should be used between the three-way switches. White insulated wires used for hot wires should be marked in each box with black plastic tape. Solderless connectors should be used to make the splices. Demonstrate stripping romex and removing the insulation from wires prior to installation.

Transparency No. 22

It is suggested that the teacher use transparency No. 20 and draw the wiring diagram. Also, students should draw the wiring diagram before actually performing the skills required to wire the demonstration board. The teacher may wish to duplicate the master for transparency No. 20 to give students practice in drawing the wiring diagram. Symbols used in drawing wiring diagrams are shown in the above transparency.

Outlet Circuit - After stripping the romex and removing the insulation from the black and white wires, place the romex into the fuse box and connect the black wire to the terminal below the fuse. Connect the white and bare wires to the neutral bar. Place the other end of the romex through the first outlet box, strip and remove the insulation. Connect the black wire to the brass screw, the white wire to the silver screw, and the bare wire to the safety-ground (green) screw. Using the same color coding, connect the first outlet to the second outlet with another length of romex. Install outlets and place covers on outlet boxes.

Lighting Circuit and Two-Way Switch - Place No. 14 two-wire romex in the fuse box. After stripping and removing the insulation, connect the black wire to the terminal below the fuse and the white wire to the neutral bar. (If romex with safety-ground is used, connect the bare wire to the neutral bar.)

Carry the other end of the romex into the first junction box, strip and remove the insulation.

Using another length of two-wire romex, place one end into the junction box and the other end into the first switch box. (More white wire with black tape in each box.)

Another length of two-wire romex should be run from the first junction box to the second junction box for the three-way switch installation.

In the first junction box, the following splices should be made: (1) Black wire from fuse box, white wire with black tape, and black wire going to second junction box. (2) Black wire from switch box and black lead of light. (3) White wire from fuse box, white lead of light, and white wire going to second junction box. (If safety-ground wire is used, connect it to screw of junction and/or switch boxes.) Place the porcelain light fixture on the junction box for the cover and to mount the fixture.

Two-Way Switches - Connect the black wire to one terminal and the white wire to the other terminal. Install switch and cover.

Three-Way Switches - Using three-wire romex, run a length from the junction box to one switch box and a separate length from the junction box to the other switch box.

In the three-way switch boxes, connect the black wire of the three-wire romex to the common terminal and the red and white wires to the traveler terminals. The white wires should be marked with black tape.

In the second junction box, make the following splices: (1) Black wire from first junction box and black wire from one three-way switch. (2) Black lead of light and black wire from the second three-way switch. (3) Red traveler wires. (4) White traveler wires (marked with black tape). (5) White wire from first junction box and white lead of light.

Mount the porcelain light fixture on the junction box and install three-way switches and covers.

Energize the fuse box and check the circuits and switches to determine if they function properly. Note: Since the safety-ground wire is used, it is most important that the circuit be polarized when energized. Polarizing the circuit means that the neutral wire is connected to the neutral wire of the circuit board.

13. Planning the Farm Wiring System

The farm wiring system includes both exterior and interior wiring, and extends from the point of supply to various outlets located inside and outside of farm buildings. A well-planned wiring system can pay the farmer dividends by reducing the size of wire, size of electrical equipment needed, amount of wire used, installation labor, and the amount of electricity used.

A procedure that may be used in planning a farm wiring system is given below:

1. Prepare a farmstead plan.
    - a. Buildings are drawn to scale (size and respective location of buildings).
    - b. Present power supply source is included.
2. Determine number of circuits needed in each building.
    - a. Plan is prepared for each separate building.

    (A residence is used as an example.)
    - (1) General purpose circuits
        - (a) The number of outlets needed is determine by taking the floor plan and spacing at least one convenience outlet for every 12 feet of wall space. This spacing provides a circuit for any appliance having an extension cord six feet long. No more than eight convenience or lighting outlets should be on one circuit, and this number is too many for the kitchen. An adequate number of lighting outlets should also be determined. The number and size of light fixtures is determined by the amount of floor space in a given area and the amount of candle power of the fixture.

Although there is some difference in the number of outlets needed in a residence and other farm buildings, a number of convenience outlets are required in most farm buildings.

(b) Because of the high wattage of many kitchen appliances, at least two general purpose circuits should be provided in this area.

(c) Number 12 wire is used for general purpose circuits, and the circuits are protected with 15 or 20 ampere fuses or circuit breakers.

(2) Special Purpose Circuits

(a) These are provided for appliances such as range, water heater, air conditioner, food freezer, water system, and clothes dryer. The size of wire used in special circuits is based on safe ampere capacity and permissible voltage drop.

(b) Graphical electric symbols are placed on the building floor plan to indicate 120-volt outlets, 240-volt outlets, etc.

(c) Select service entrance panel.

(1) The service entrance cables and service equipment are capacity rated and should have a rating that is adequate to handle the electrical load safely. A farm home with central heat and air conditioning may require equipment with a capacity to handle as much as 200 amperes.

(2) A distribution panel with 20 to 24 branch circuit positions is recommended for the home. Some of the branch circuit positions that may be required in a residence are given below:

BRANCH CIRCUIT POSITIONS NEEDED

Electric Range (240 v)	2
Clothes Dryer (120/240 v)	2
Water Heater (240 v)	2
Automatic Washer (120 v)	1
Freezer (120 v)	1
Appliance Circuits (120 v)	2 (est)
Water Pump (120 or 240 v)	1 or 2
Lighting Circuits (120 v)	4 (est)
Fuel-Fired Heating System (120 v)	1
Dishwasher (120 v)	1
Waste Disposer (120 v)	1
Air Conditioner (240 v)	2
Spares	2 or 3
	24

The "Agricultural Wiring Handbook," a reference for this topic, can be used in planning the wiring layout in other buildings.

3. Consult power supplier to determine the location of the meter (pole or building).

   The meter pole should be located in an area that is accessible to power supplier, but not in an area that will interfere with the operation of the farm. Normally, the meter is centrally located from the standpoint of electrical load. It is possible that the meter location can reduce wiring expenses by reducing the wire size used in feeder circuits to buildings.

4. Select feeder circuit wire sizes
   The "Agricultural Wiring Handbook" can be used in making these selections.

5. Consult with power supplier on "meter loop" requirements.

References:

1. "Farm Electrification Lesson Plans - Wiring and Safety", Texas Education Agency and Vocational Instructional Services, Texas A&M University, College Station, Texas, 1973

2. "Agricultural Wiring Handbook", Farm Electrification Council, Inc. and others, 909 University Ave., Columbia, Missouri, 1976

3. "Electrical Wiring - Fundamentals and Planning", Vocational Agriculture Service, University of Illinois, Urbana, Illinois, 1970

4. "Electrical Controls and Basic Control Circuits Used In Agricultural Production", Texas Education Agency and Vocational Instructional Services, Texas A&M University, College Station, Texas, 1973

Allowable Current-Carrying Capacities
of
Insulated Copper and Aluminum Conductors in Amperes

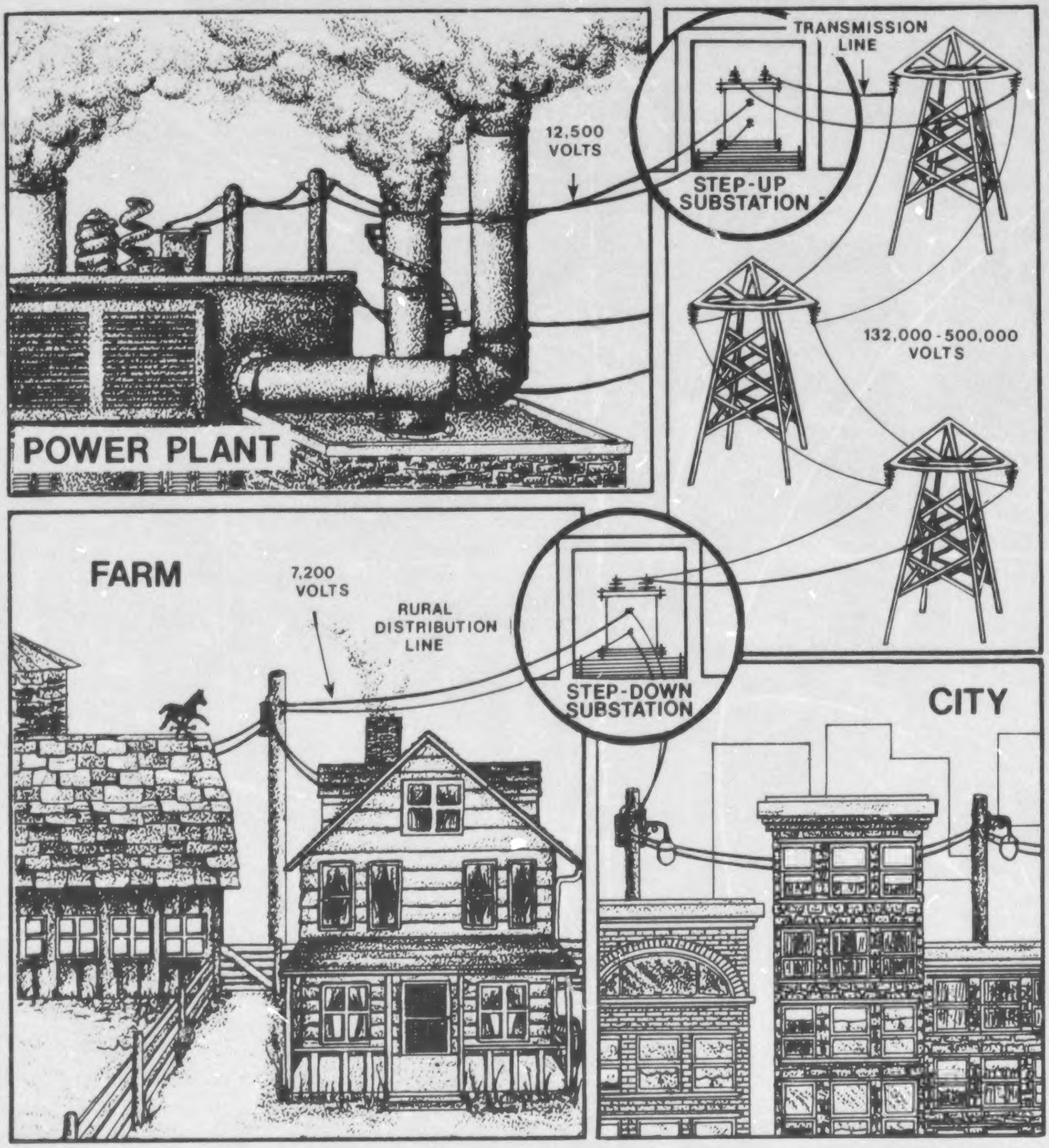
	A Not more Than Three Conductors in Raceway or Cable, or Direct Burial				B Single Conductors in Free Air			
Size AWG or MCM	1 Rubber Insulation, Type R, RW, RU, RUW Type RH-RW in Wet Locations Thermoplastic Insulation, Type T, TW		2 Rubber Insulation, Type RH, RHW Type RH-RW in Dry Locations		3 Weatherproof Insulation, Type WP		4 Thermoplastic Insulation, Type TW	
	Copper	Aluminum	Copper	Aluminum	Copper	Aluminum	Copper	Aluminum
14	15	--	15		xx	xx	xx	xx
12	20	15	20	15	xx	xx	xx	xx
10	30	25	30	25	55	45	40	30
8	40	30	45	40	70	55	55	45
6	55	40	65	50	100	80	80	60
4	70	55	85	65	130	100	105	80
3	80	65	100	75	150	115	120	95
2	95	75*	115	90*	175	135	140	110
1	110	85*	130	100*	205	160	165	130
0	125	100*	150	120*	235	185	195	150
00	145	115*	175	135*	275	215	225	175
000	165	130*	200	155*	320	250	260	200
0000	195	155*	230	180*	370	290	300	230
250	215	170	255	205	410	320	340	265
300	240	190	285	230	460	360	375	290
350	260	210	310	250	510	400	420	330
400	280	225	335	270	555	435	455	355
500	320	260	380	310	630	490	515	405
600	355	285	420	340	710	560	575	455
700	385	310	460	375	780	615	630	500
750	400	320	425	385	810	640	655	515

If bare conductors are used with insulated conductors, their allowable current-carrying capacity shall be limited to that permitted for insulated conductors of the same size.

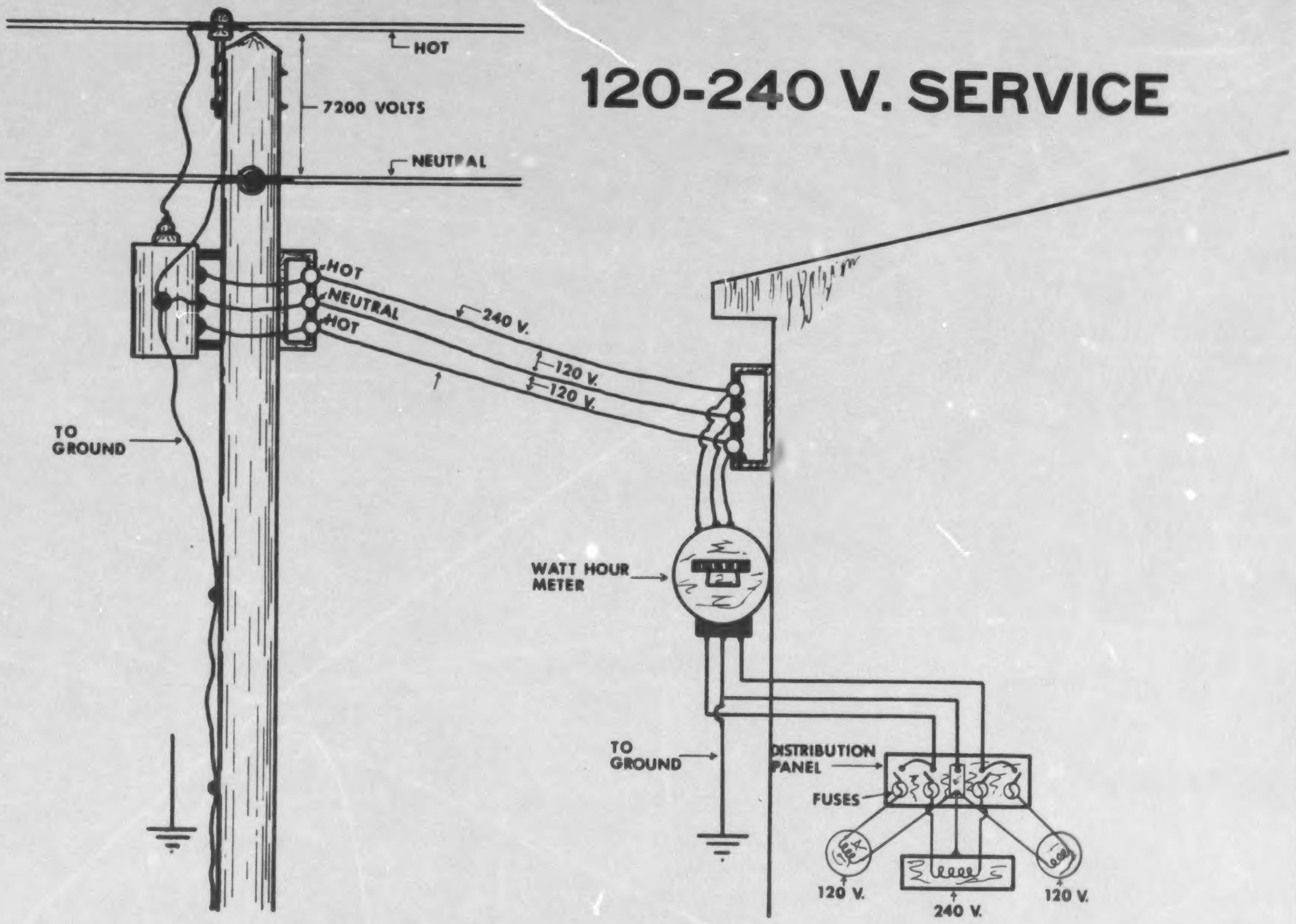
* For three-wire, single-phase service and sub-service circuits, the allowable current-carrying capacity of RH, RH-RW, RHH and RHW aluminum conductors shall be for sizes No. 2-100 amp, No. 1-110 amp, No. 1/0-125 amp, No. 2/0-150 amp, No. 3/0-170 amp and No. 4/0-200 amp.

xx No. 10 is minimum permissible in overhead spans up to 50 ft. in length. For spans over 50 ft. in length, No. 8 is minimum permissible. See 1956 NE Code, Section 7314b.

HOW ELECTRICITY GETS TO THE FARM


TRANSMISSION LINE
12,500 VOLTS
STEP-UP SUBSTATION
POWER PLANT
132,000-500,000 VOLTS
FARM
7,200 VOLTS
RURAL DISTRIBUTION LINE
STEP-DOWN SUBSTATION
CITY

120-240 V. SERVICE


HOT
7200 VOLTS
NEUTRAL
HOT
NEUTRAL
HOT
240 V.
120 V.
120 V.
TO GROUND
WATT HOUR METER
TO GROUND
DISTRIBUTION PANEL
FUSES
120 V.
240 V.
120 V.

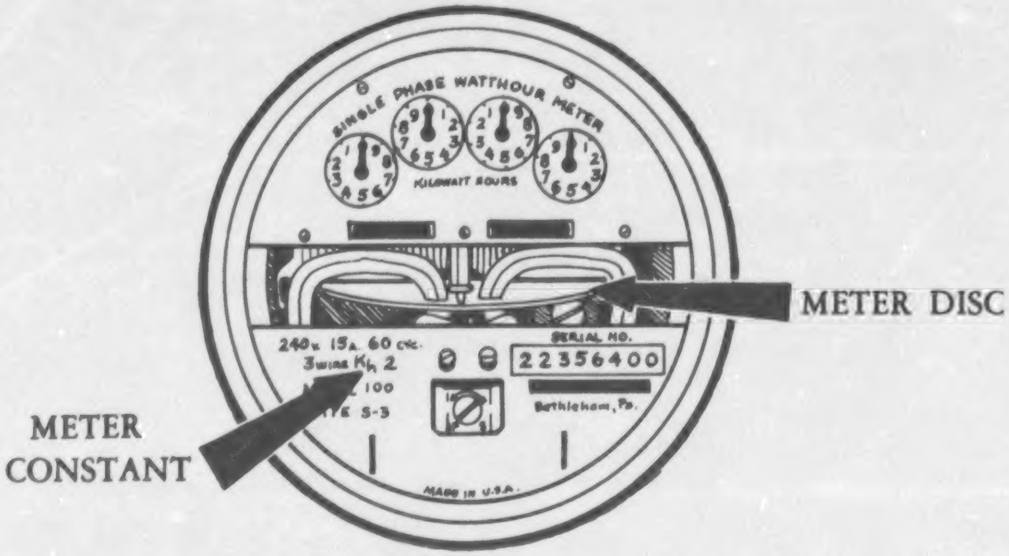
COST OF OPERATING ELECTRICAL EQUIPMENT

Doe's Product Co.
Bryan, Tx
Model # 105 E
Watts 550
Volts 120

UL
Household Appliance

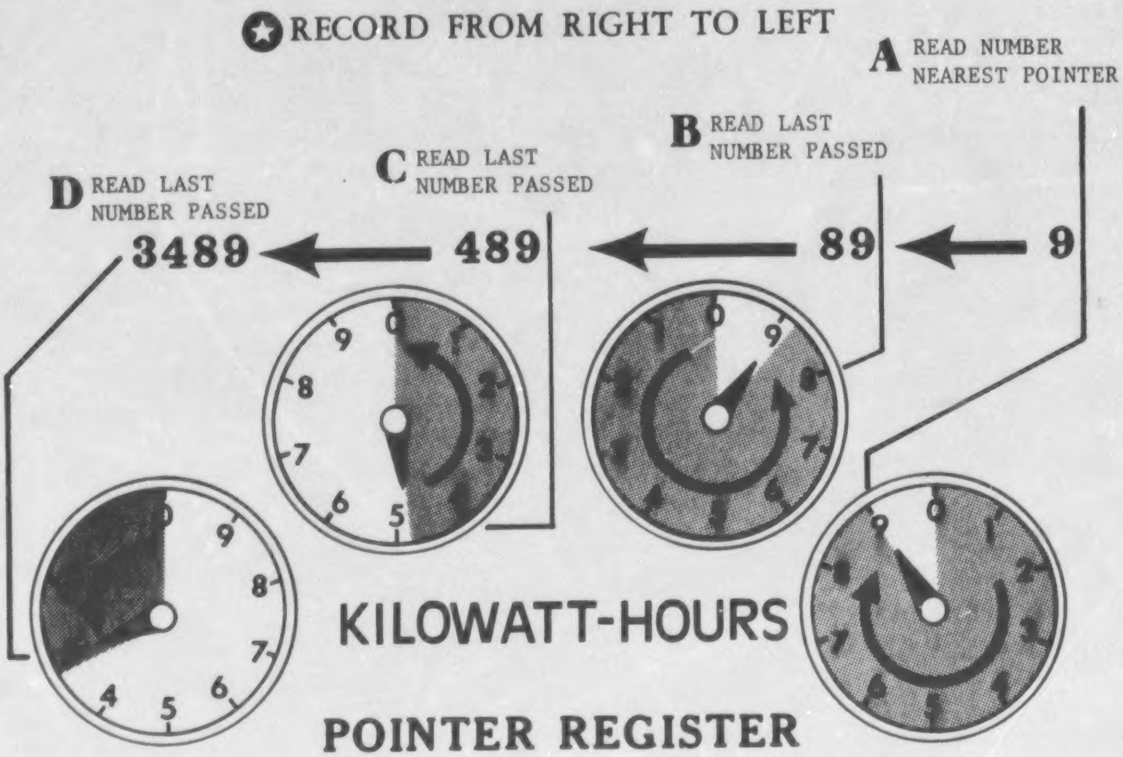
COFFEE POT NAME PLATE

Step No. 1 - 550 watts
Step No. 2 - 8 hours per month
Step No. 3 - 550 x 8 = 4,400 watt-hours
Step No. 4 - 4,400 ÷ 1,000 = 4.4 kilowatt-hours
Step No. 5 - 4¢ (charges per kwh) x 4.4 = 17.6 or 18¢

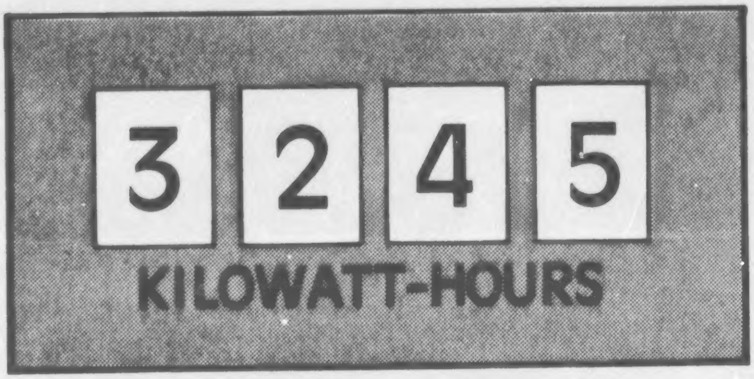

SINGLE PHASE WATTHOUR METER
KILOWATT HOURS
240v 15A 60 cyc.
3wire Kh 2
100
S-3
SERIAL NO.
22356400
Bethlehem, Pa.
MADE IN U.S.A.
METER DISC
METER CONSTANT

2 (kh) x 60 (rev. per period) = 120 x 10 (time periods in hr.) = 1200 x 240 (hrs. used per month) = 288,000 ÷ 1,000 = 288 (kwh) x .04 (cost per kwh) = $11.52 cost per month

ELECTRIC METER REGISTERS

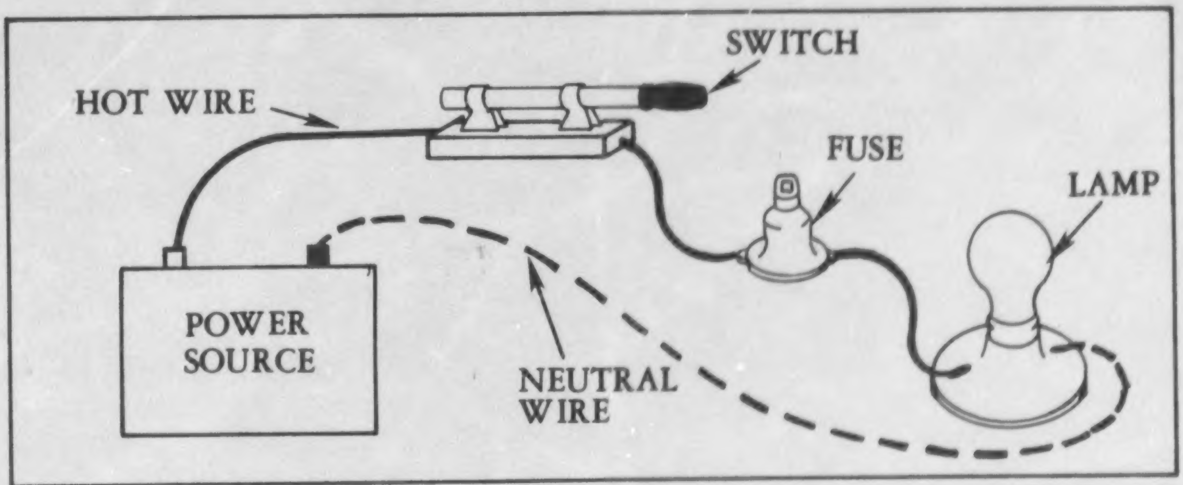

RECORD FROM RIGHT TO LEFT
A READ NUMBER NEAREST POINTER
B READ LAST NUMBER PASSED
C READ LAST NUMBER PASSED
D READ LAST NUMBER PASSED
3489
489
89
9
KILOWATT-HOURS

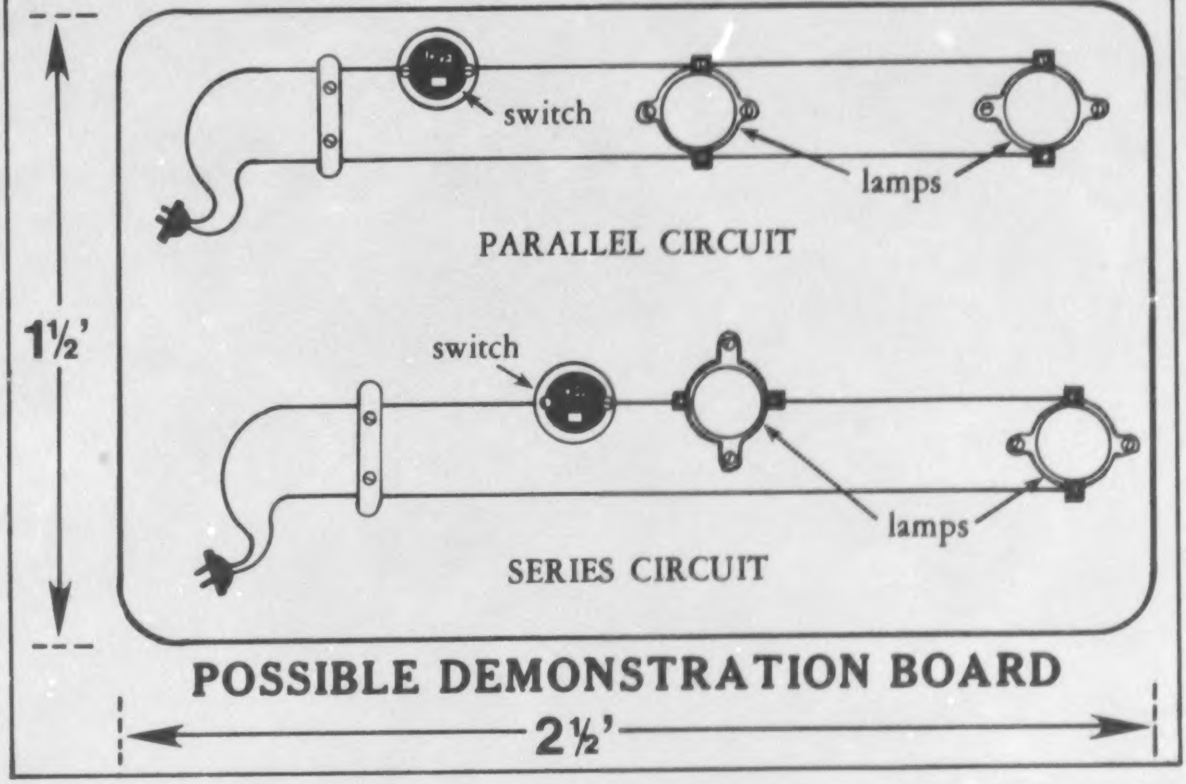
POINTER REGISTER


3245
KILOWATT-HOURS

ODOMETER REGISTER

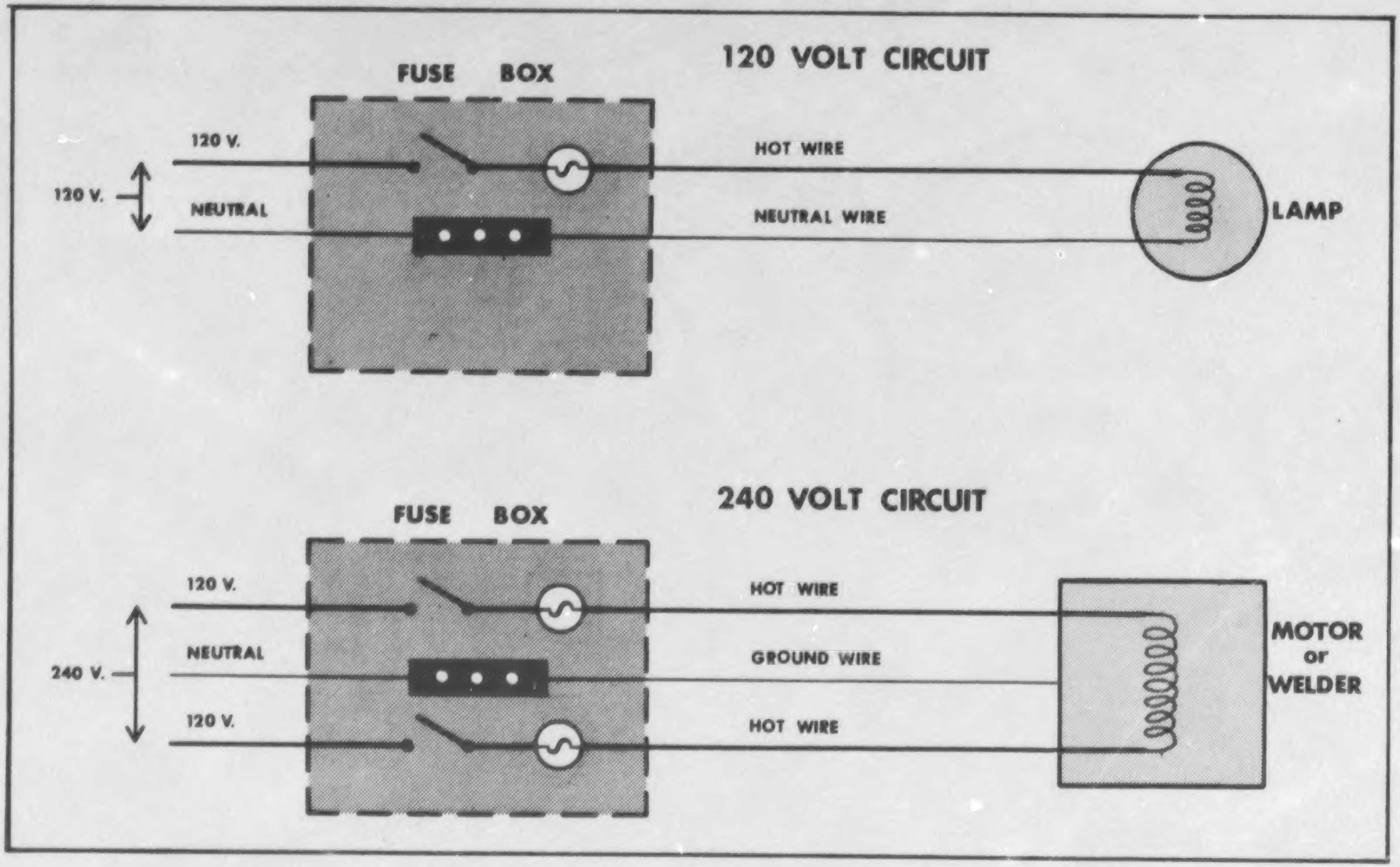
SIMPLE CIRCUITS


SWITCH
HOT WIRE
FUSE
LAMP
POWER SOURCE
NEUTRAL WIRE

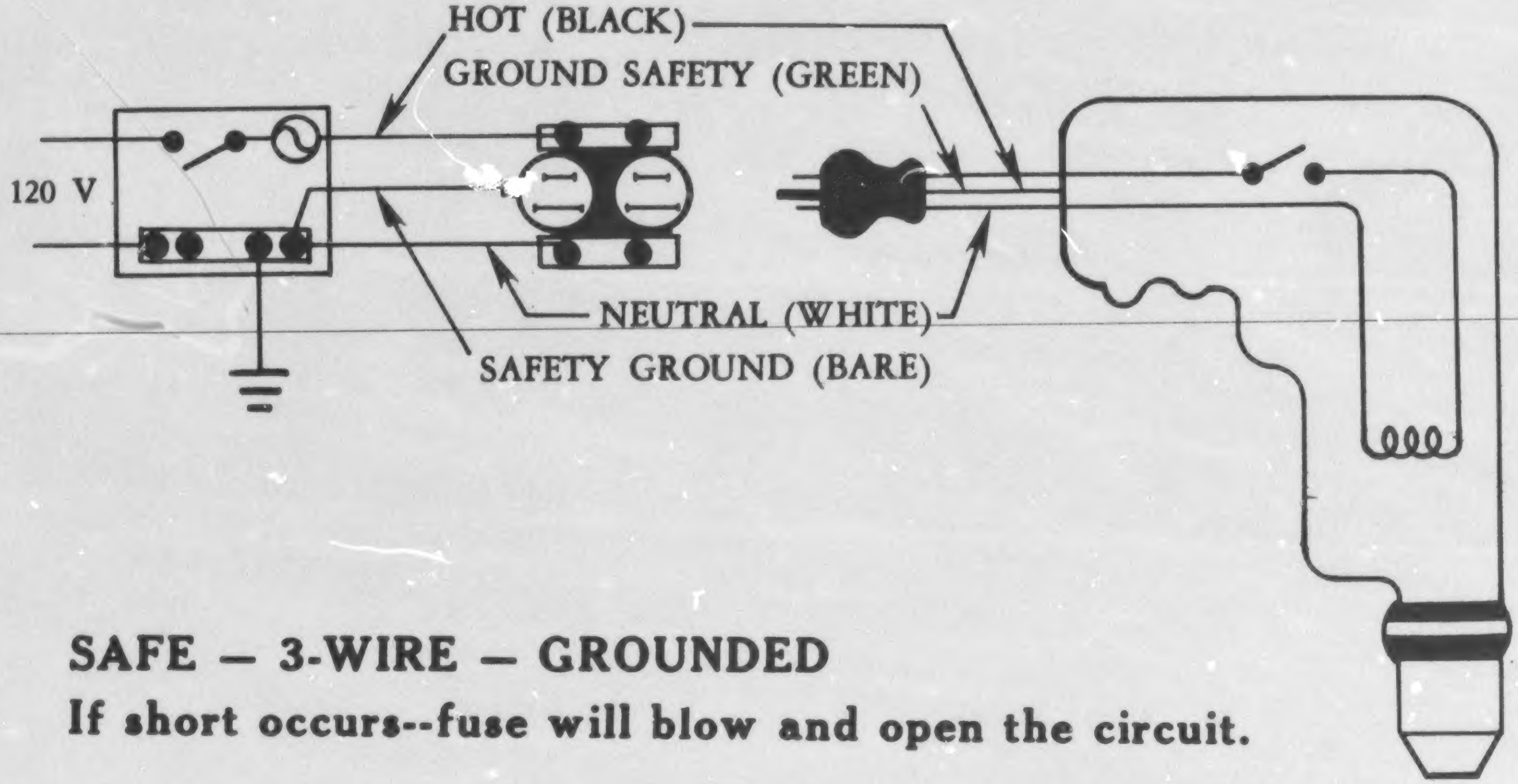

switch
lamps
PARALLEL CIRCUIT
1½'
switch
lamps
SERIES CIRCUIT
2½'

POSSIBLE DEMONSTRATION BOARD

120-240 VOLT CIRCUITS


120 VOLT CIRCUIT
FUSE BOX
120 V.
120 V.
NEUTRAL
HOT WIRE
NEUTRAL WIRE
LAMP
240 VOLT CIRCUIT
FUSE BOX
120 V.
240 V.
NEUTRAL
120 V.
HOT WIRE
GROUND WIRE
HOT WIRE
MOTOR
or
WELDER

SAFETY-GROUNDING AN ELECTRIC DRILL


HOT (BLACK)
GROUND SAFETY (GREEN)
120 V
NEUTRAL (WHITE)
SAFETY GROUND (BARE)

SAFE – 3-WIRE – GROUNDED

If short occurs--fuse will blow and open the circuit.

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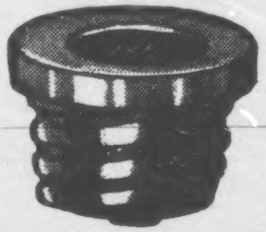
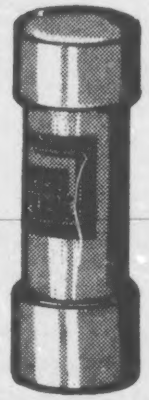
CIRCUIT PROTECTION

① COMMON FUSES



PLUG



CARTRIDGE

② FUSETRONS (time delay action)

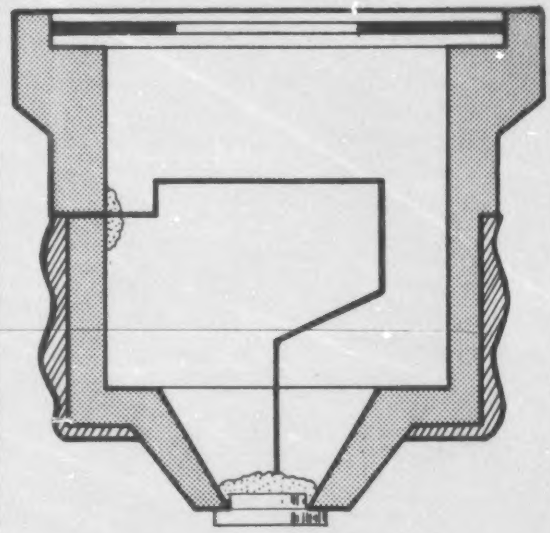
PLUG CARTRIDGE

③ FUSTATS (time delay action)

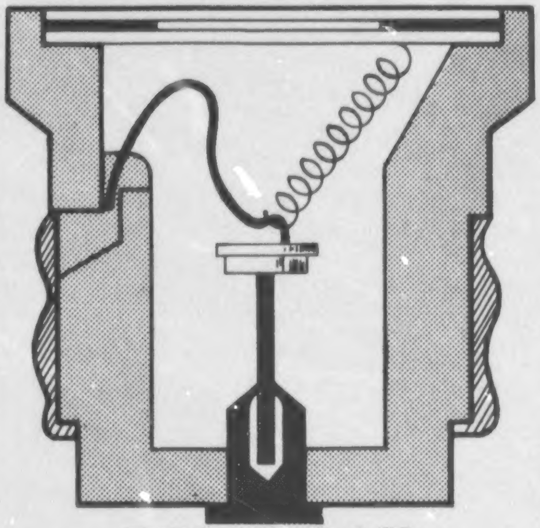
④ CIRCUIT BREAKERS

(time delay action)

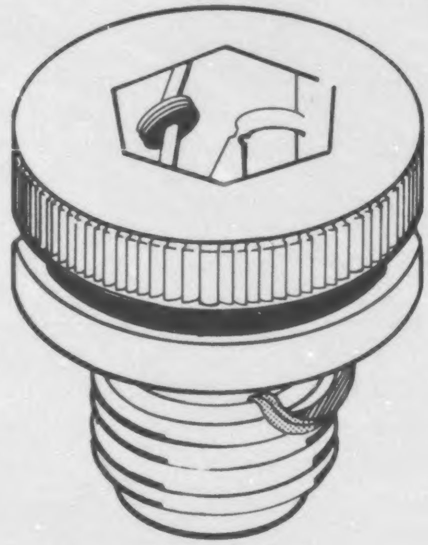
TYPES OF FUSES



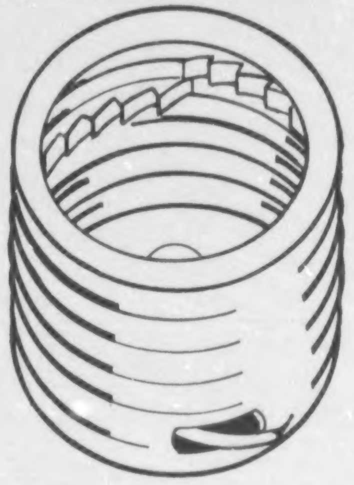
PLUG FUSE



TIME DELAY FUSE

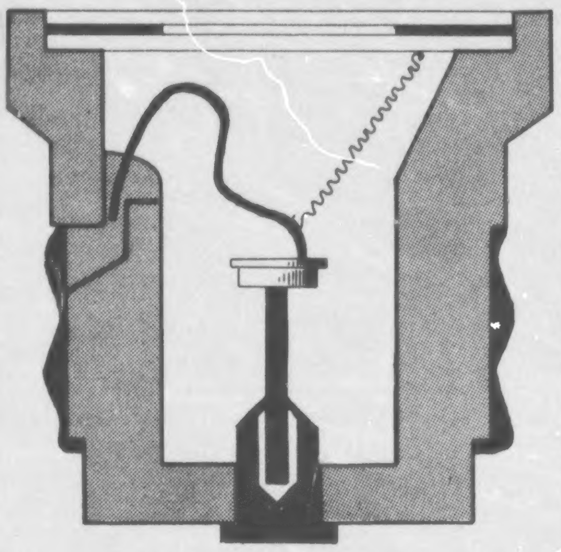


FUSTAT

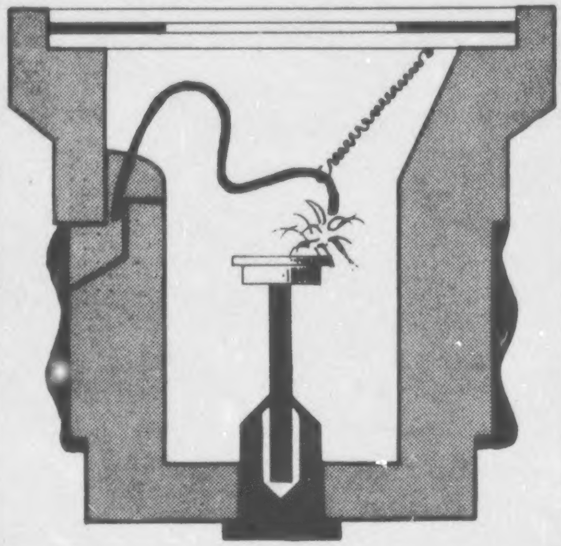


ADAPTER

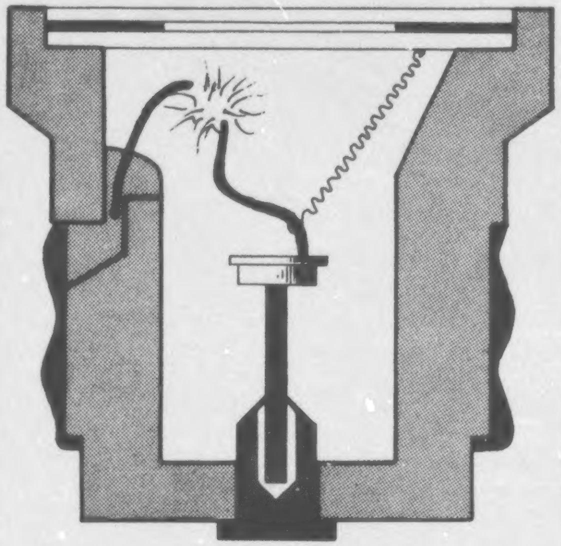
OPERATING PRINCIPLE OF A DELAYED ACTION FUSE



NORMAL

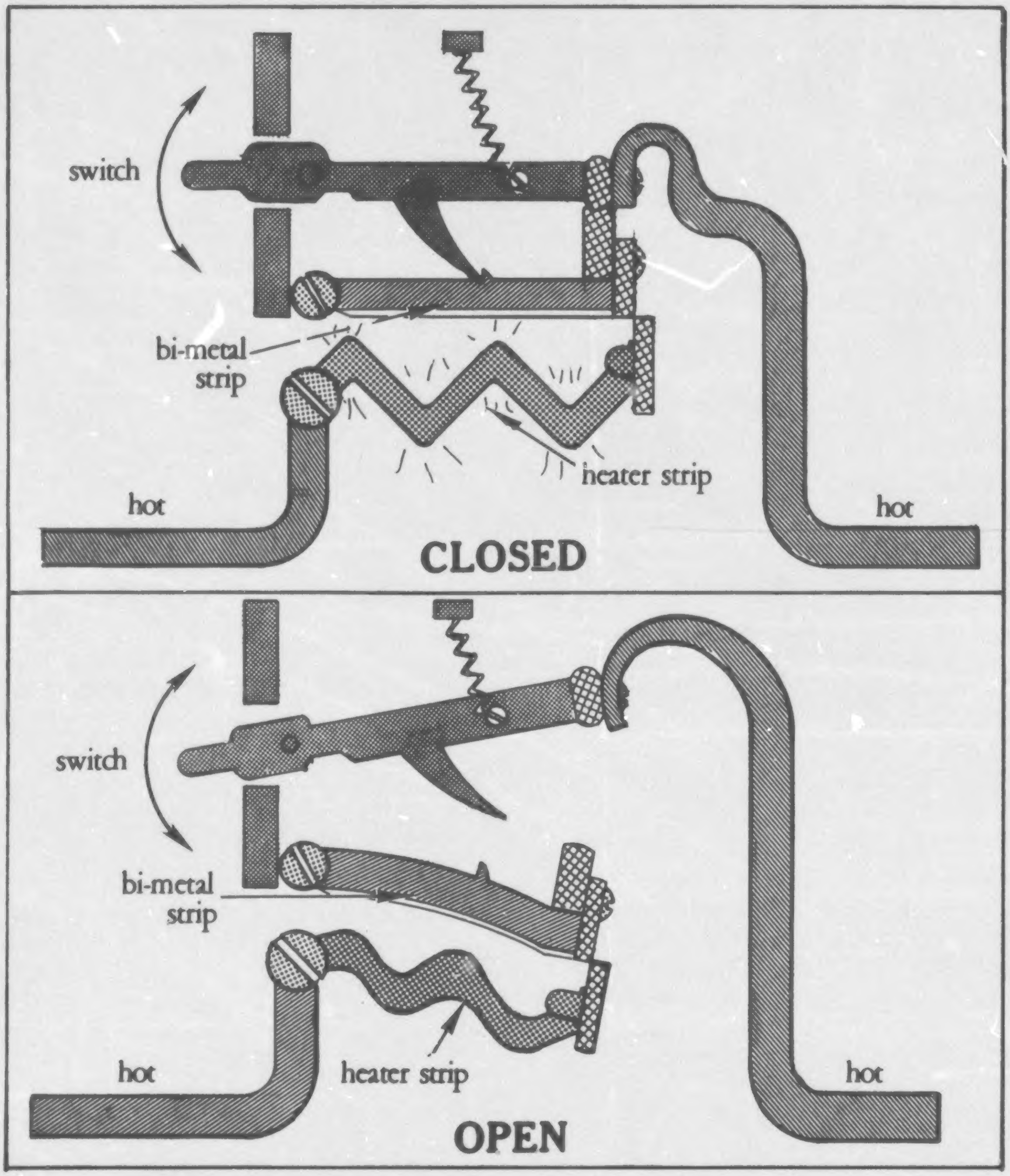


CONTINUED OVERLOAD



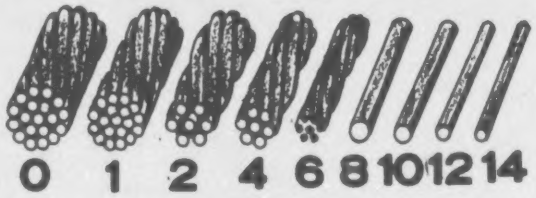
SHORT CIRCUIT

CIRCUIT BREAKER


switch
bi-metal strip
heater strip
hot
hot
CLOSED
switch
bi-metal strip
heater strip
hot
hot
OPEN

CONDUCTORS - SIZE & TYPE

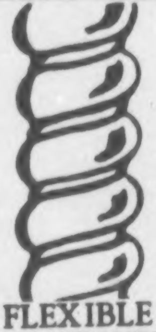
ACTUAL SIZE OF WIRE



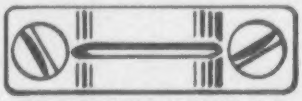
OUTDOOR WIRE TYPES	USES
UF - underground feeder	Buried underground
USE - underground service entrance	Mechanical protection required where they enter and leave ground
SE or SEU - service entrance unarmored	To bring current into buildings
ASE - armored service entrance	Same as SE

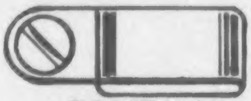
INDOOR WIRE TYPES	USES
T - thermoplastic	Inside buildings
TW - thermoplastic moisture resistant	In areas with moisture
RH - rubber, heat resistant	Carry higher voltage than T or TW
RHW - rubber, heat and moisture resistant	Service entrance or large appliance
NM - nonmetallic cable (romex)	Inside buildings

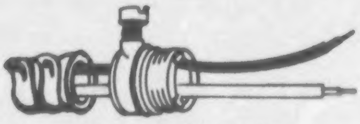
WIRING MATERIALS

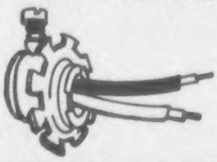

FLEXIBLE CONDUIT

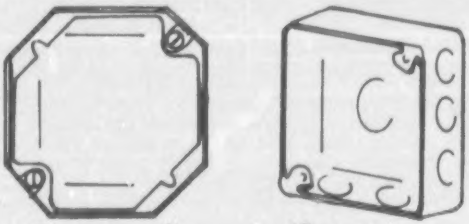
THINWALL or RIGID CONDUIT


CONDUIT STRAP

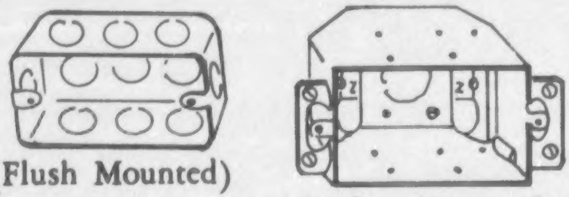

CONDUIT CONNECTOR


CONNECTOR

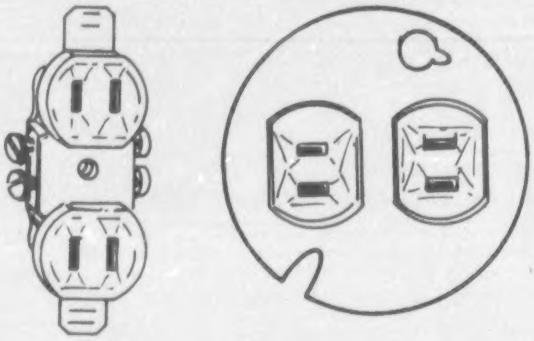

SCREW LOCK

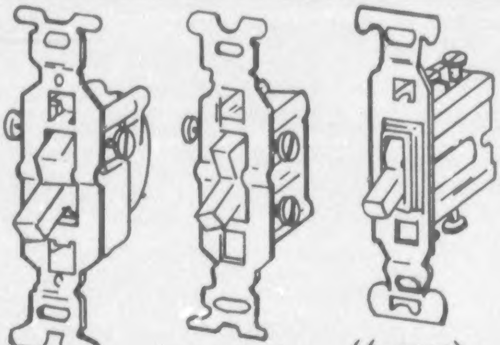

(Octagonal) (Square)

OUTLET BOXES

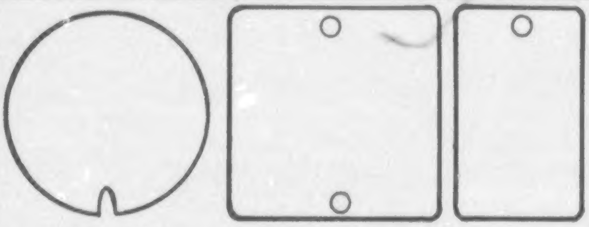

(Flush Mounted) (Surface Mounted)

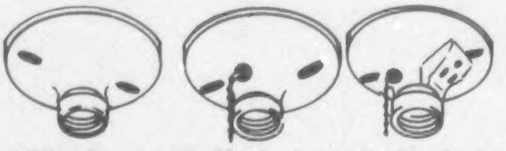
SWITCH BOXES


DUPLEX RECEPTACLES


(Single Pole) (3-way) (4-way)

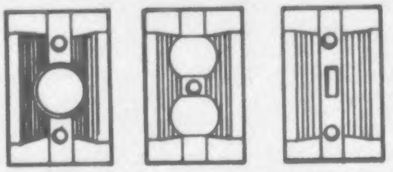
TOGGLE SWITCHES

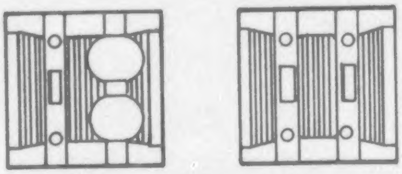

BLANK COVERS FOR BOXES

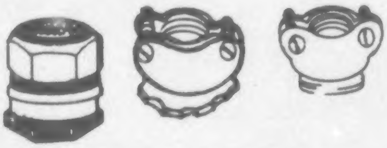

(Keyless) (Pull-chain) (Pull-chain w/outlet)

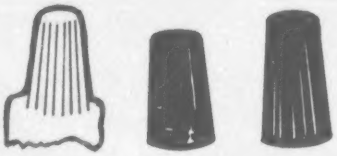
PORCELAIN RECEPTACLES

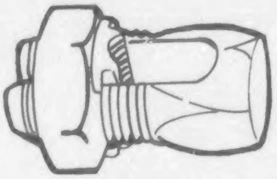
WIRING MATERIALS

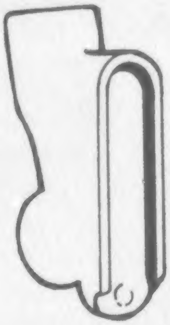

WALL PLATE COVERS

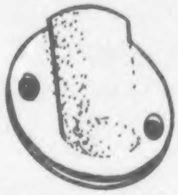

MULTIPLE GANG PLATES

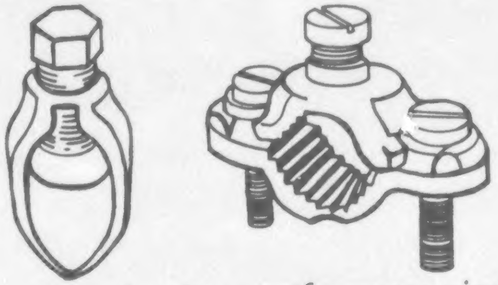

CABLE CONNECTORS


SOLDERLESS CONNECTORS

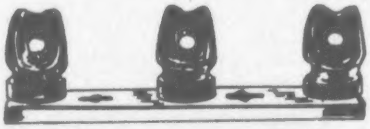

SPLIT BOLT CONNECTOR

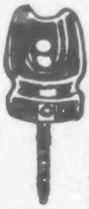

ENTRANCE ELBOW

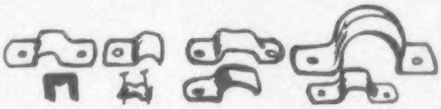

SILL PLATE


(for ground rod) (for water pipe)

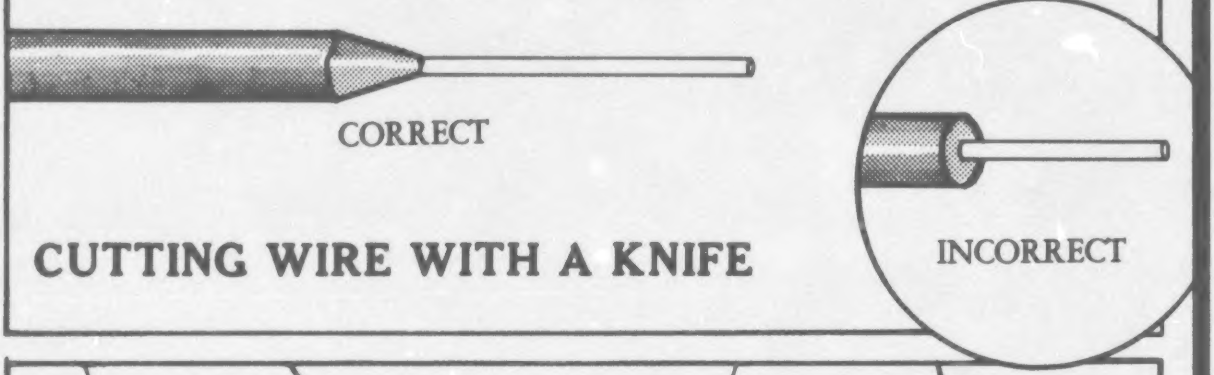
GROUND CLAMPS


INSULATOR RACK

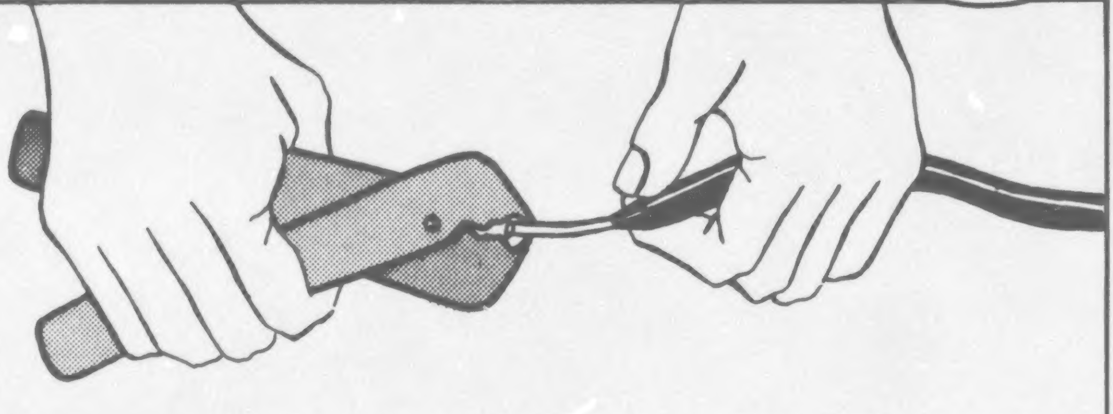

Screw Knob


STRAPS & STAPLES

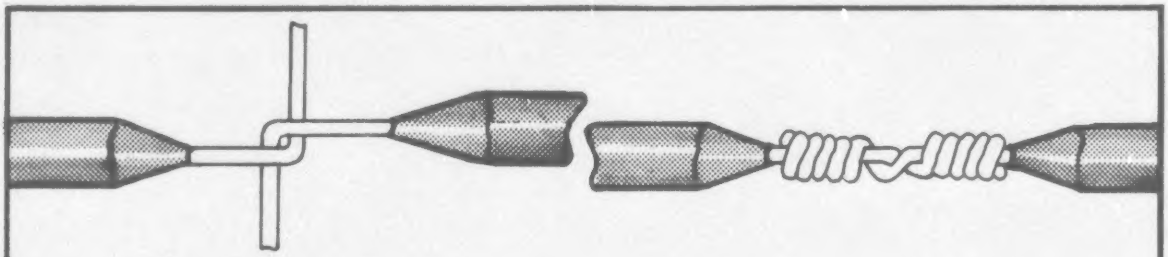
SPLICING


CORRECT
INCORRECT

CUTTING WIRE WITH A KNIFE

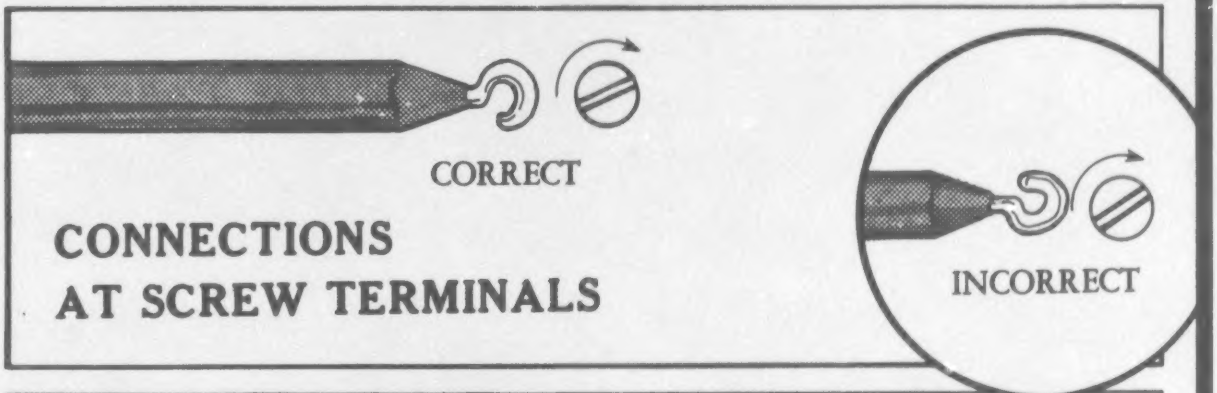


COMBINATION WIRE CUTTER AND STRIPPER

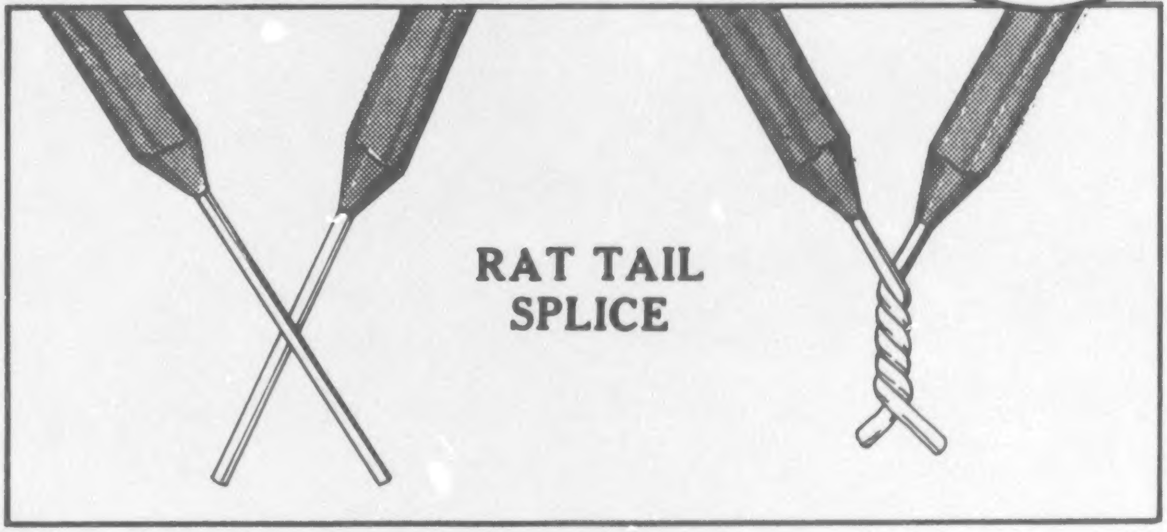


WESTERN UNION SPLICE

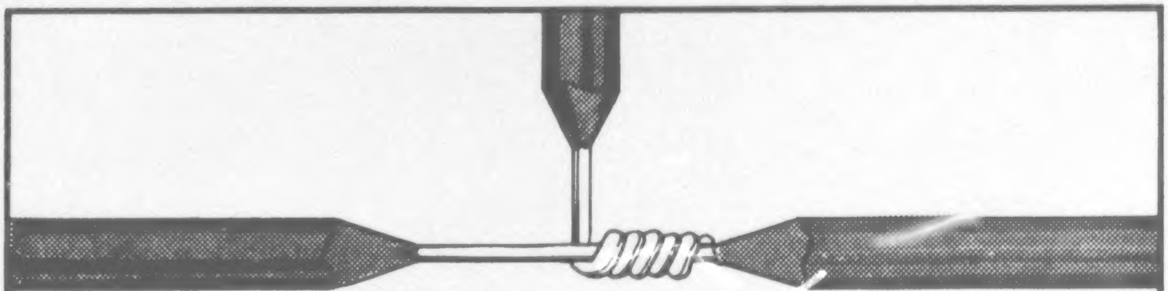
SPLICING


CORRECT
INCORRECT

CONNECTIONS AT SCREW TERMINALS

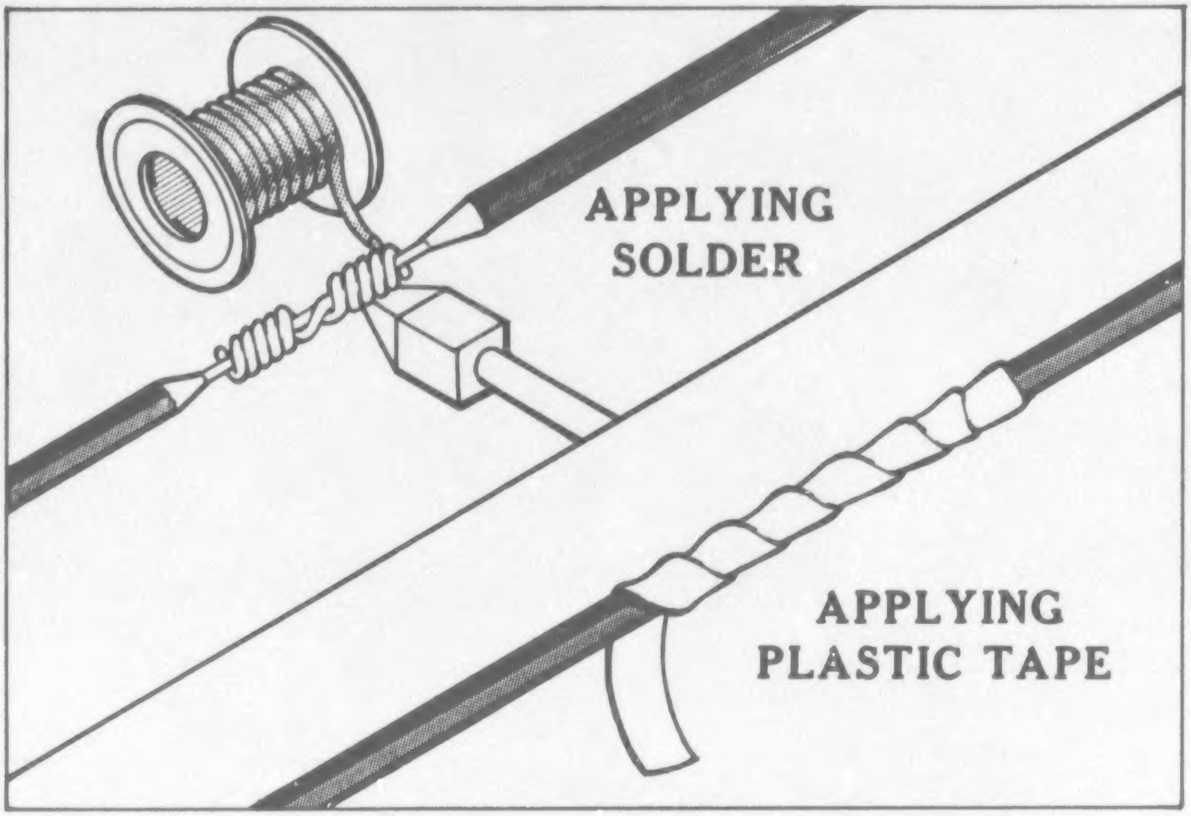


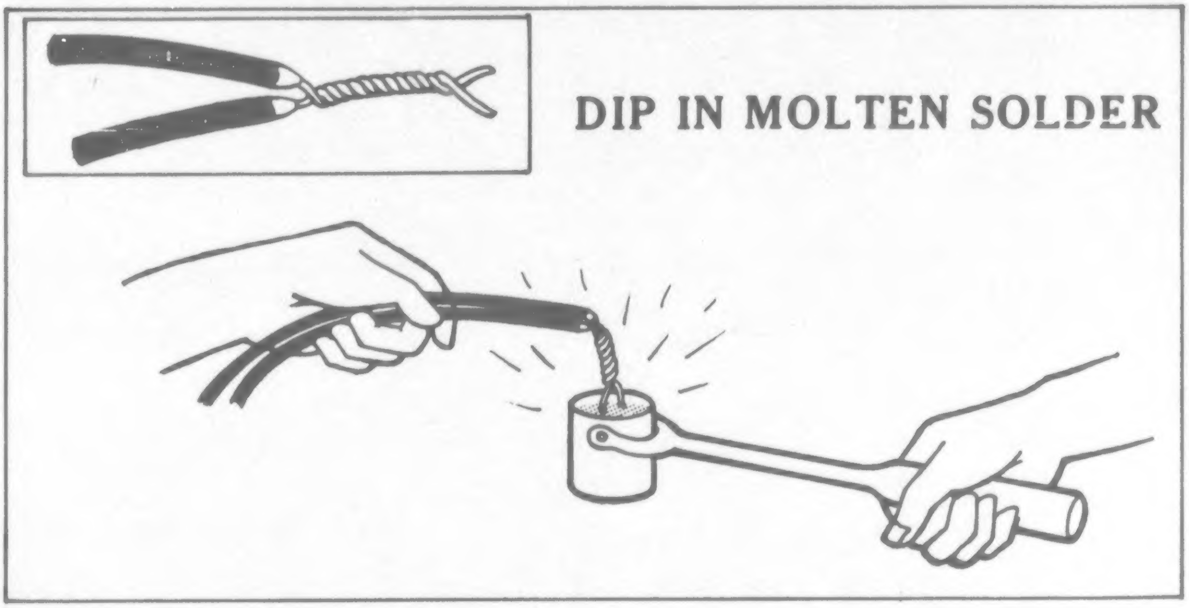
RAT TAIL SPLICE



CENTER TAP SPLICE

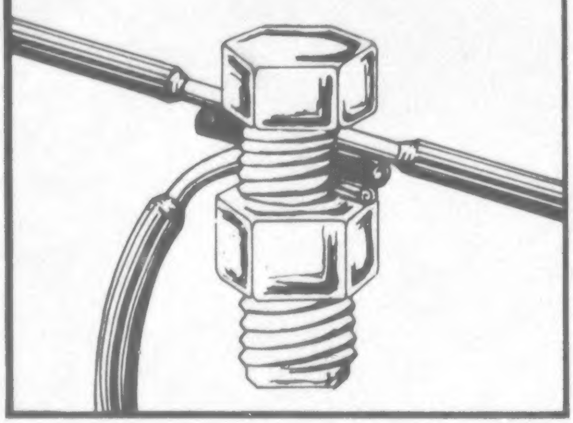
SOLDERING & TAPING

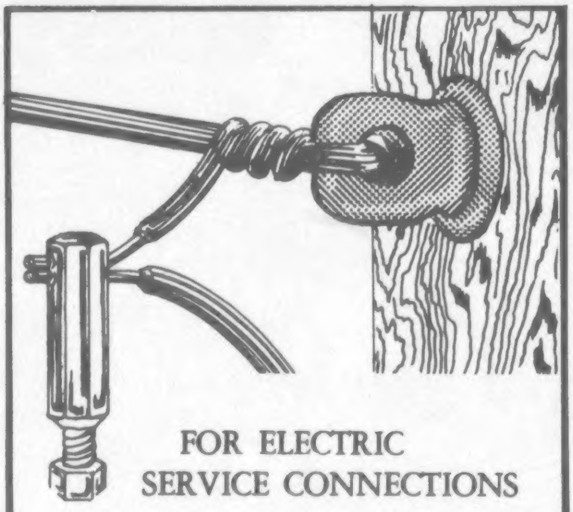

APPLYING SOLDER
APPLYING PLASTIC TAPE


DIP IN MOLTEN SOLDER

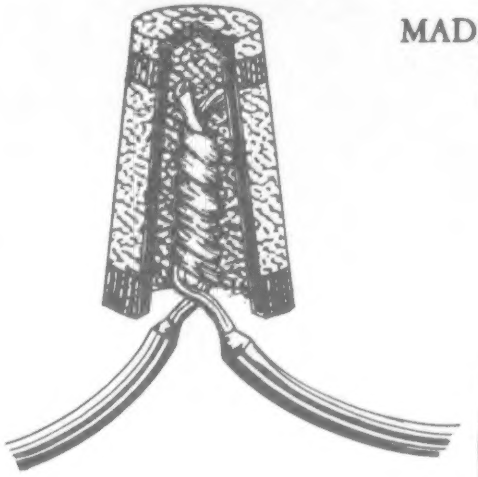
SOLDERLESS CONNECTORS

TAPS EXISTING LINE WITH STRAIN ON WIRES



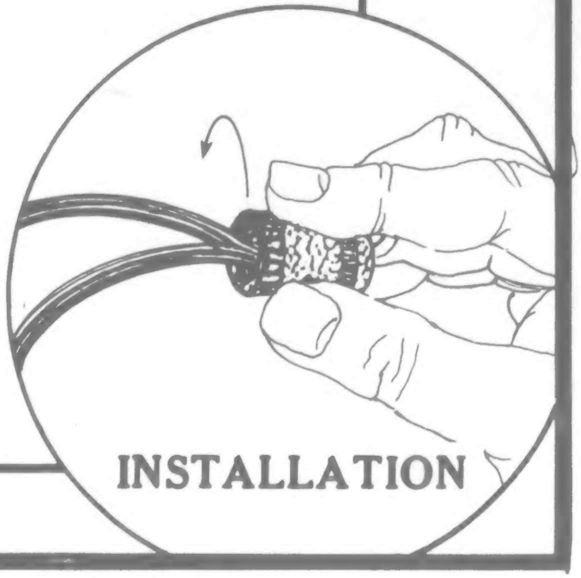


FOR ELECTRIC SERVICE CONNECTIONS



MADE OF INSULATING MATERIAL

CUT-AWAY VIEW



INSTALLATION

SIMPLE SWITCHES

SINGLE POLE - SINGLE THROW

TOGGLE - MERCURY - SILENT
ROCKER BUTTON - PUSH BUTTON

THERMOSTAT

HUMIDISTAT

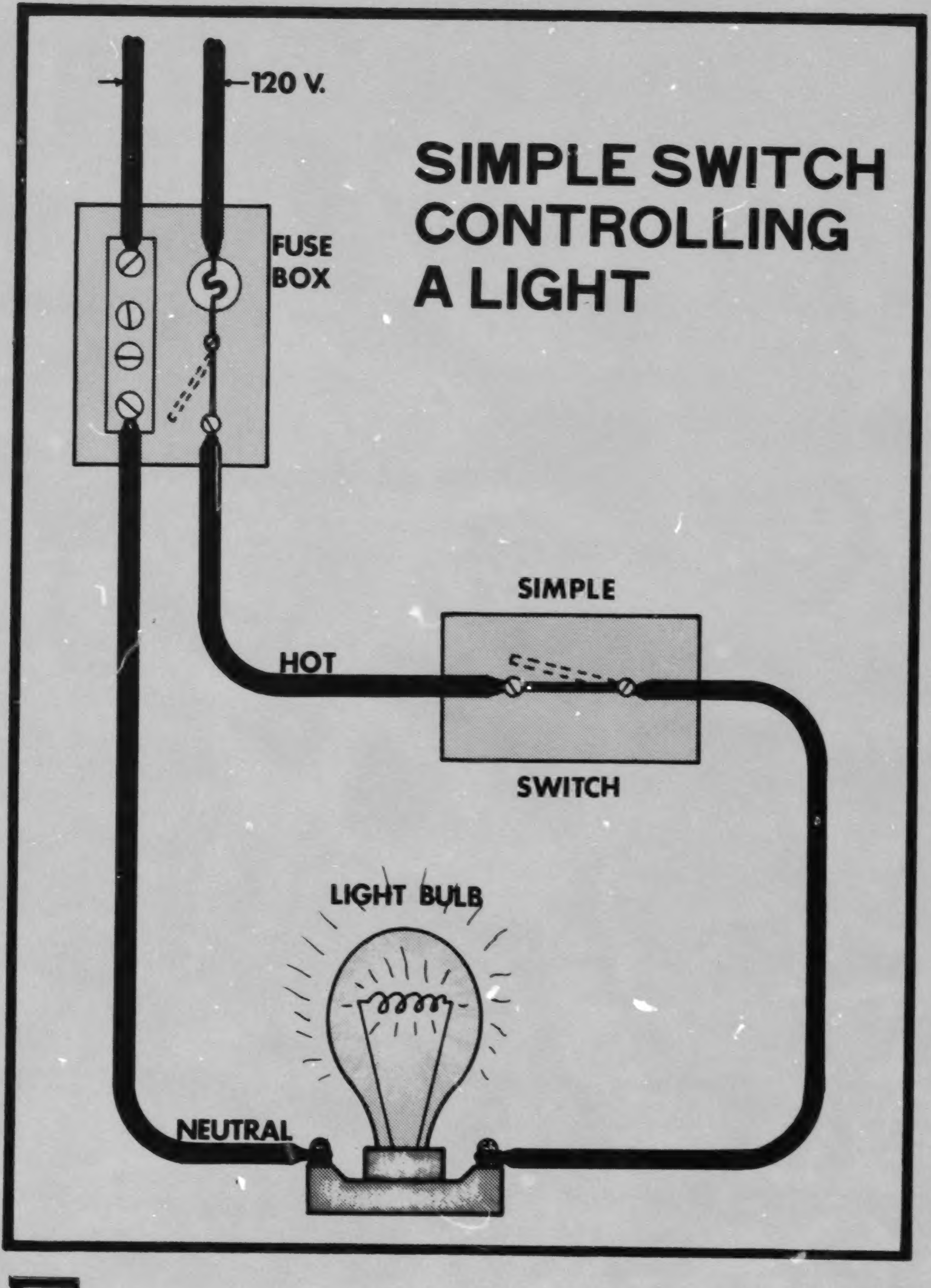
SIMPLE SWITCHES CONTROL THE CIRCUIT FROM ONE LOCATION

SIMPLE SWITCHES HAVE TWO POSITIONS - OPEN OR CLOSED

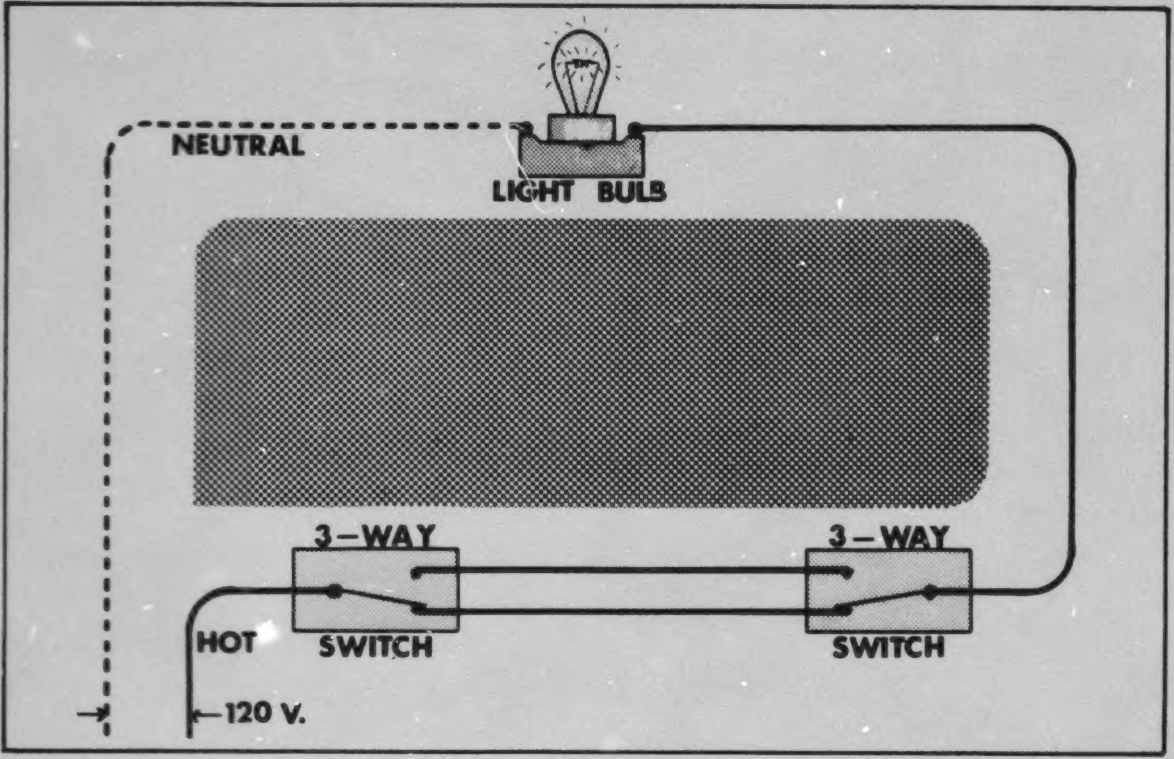
SIMPLE SWITCHES ARE NEVER INSTALLED IN A NEUTRAL LINE

SINGLE POLE SWITCHES HAVE TWO SCREWS

SIMPLE SWITCH CONTROLLING A LIGHT


120 V.
FUSE BOX
SIMPLE SWITCH
HOT
LIGHT BULB
NEUTRAL

THREE-WAY SWITCH


NEUTRAL
LIGHT BULB
3–WAY
SWITCH
3–WAY
SWITCH
HOT
120 V.

SINGLE POLE - DOUBLE THROW

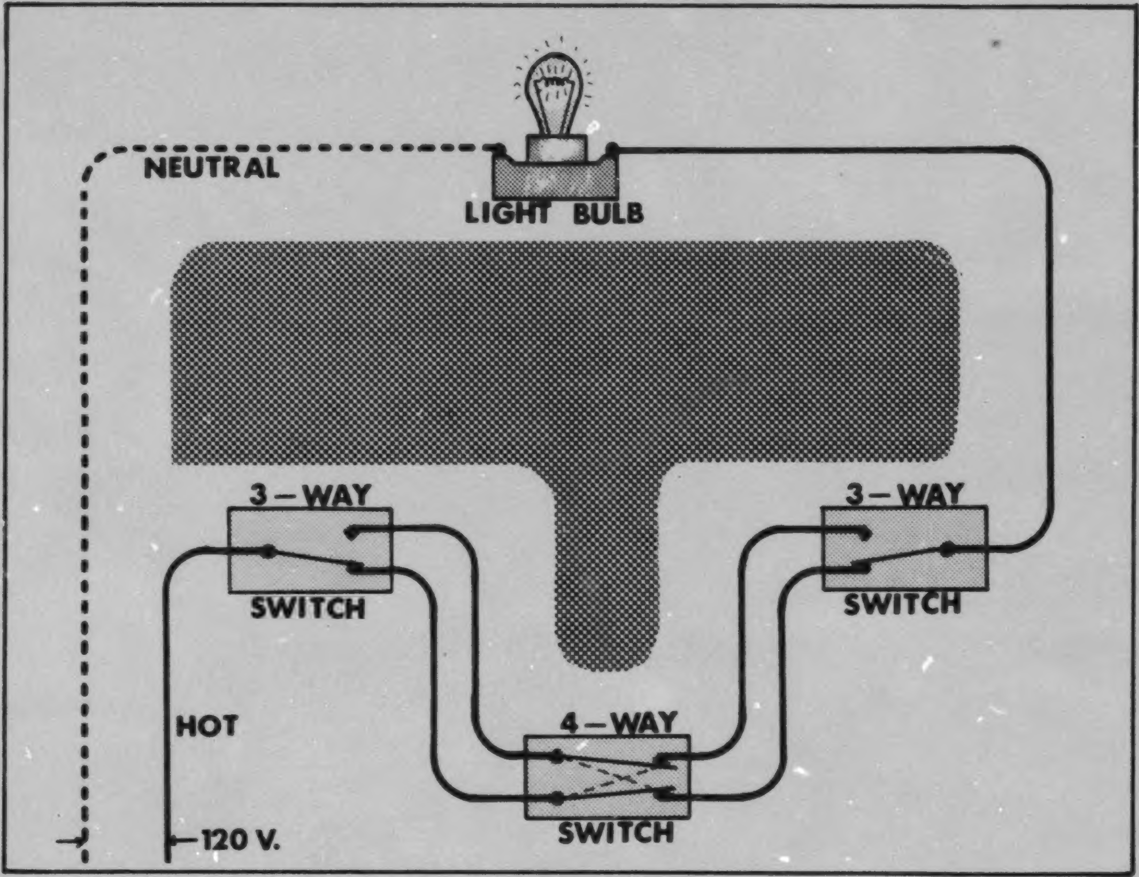
THREE SCREWS ON THE SWITCH:

One screw - common or pivot terminals

Two screws - traveler terminals

USED TO CONTROL CIRCUIT FROM
TWO LOCATIONS

FOUR-WAY SWITCH

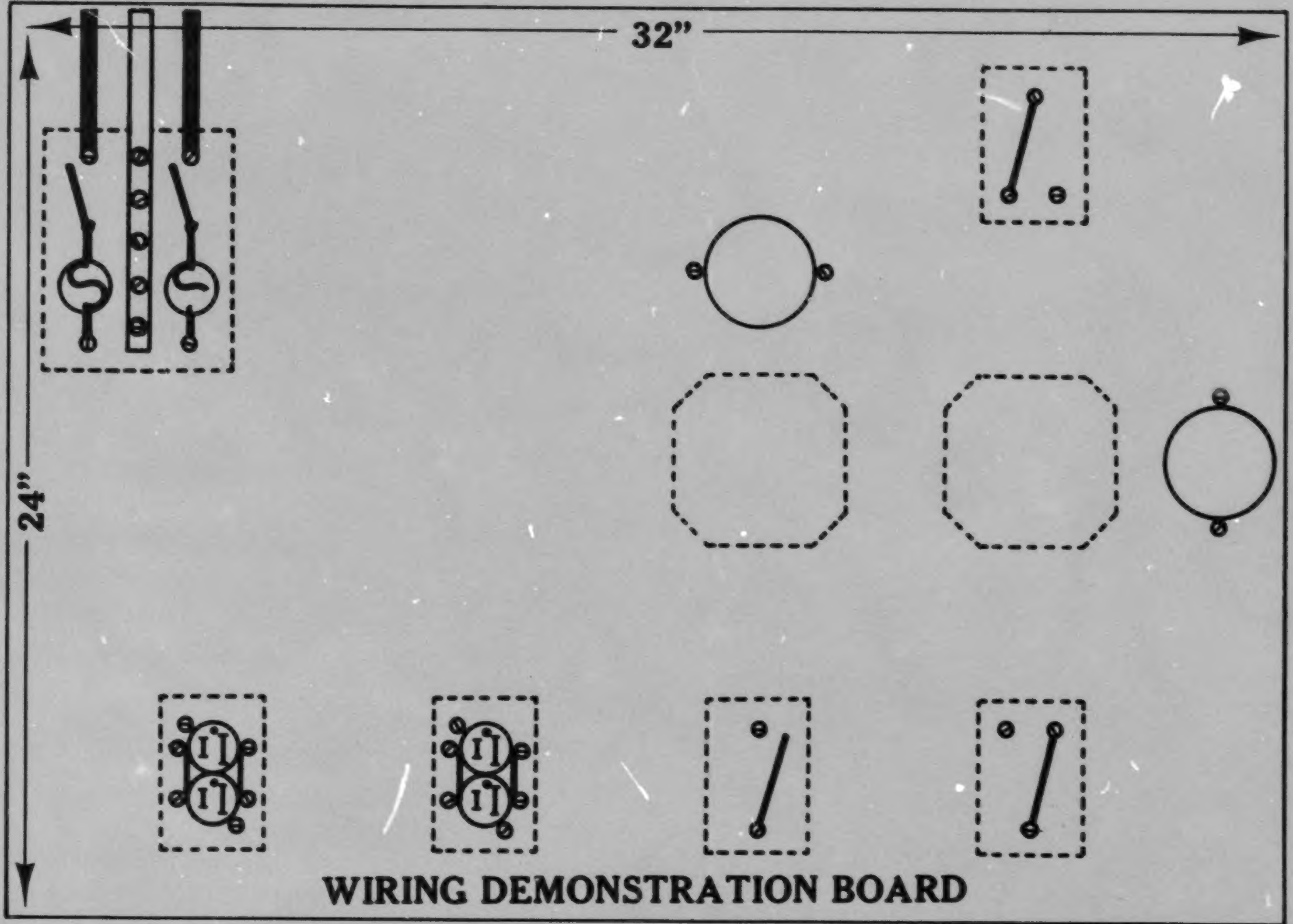

NEUTRAL
LIGHT BULB
3-WAY SWITCH
3-WAY SWITCH
4-WAY SWITCH
HOT
120 V.

FOUR SCREWS OR TERMINALS

USED BETWEEN TWO THREE-WAY SWITCHES TO CONTROL CIRCUIT FROM ANOTHER LOCATION

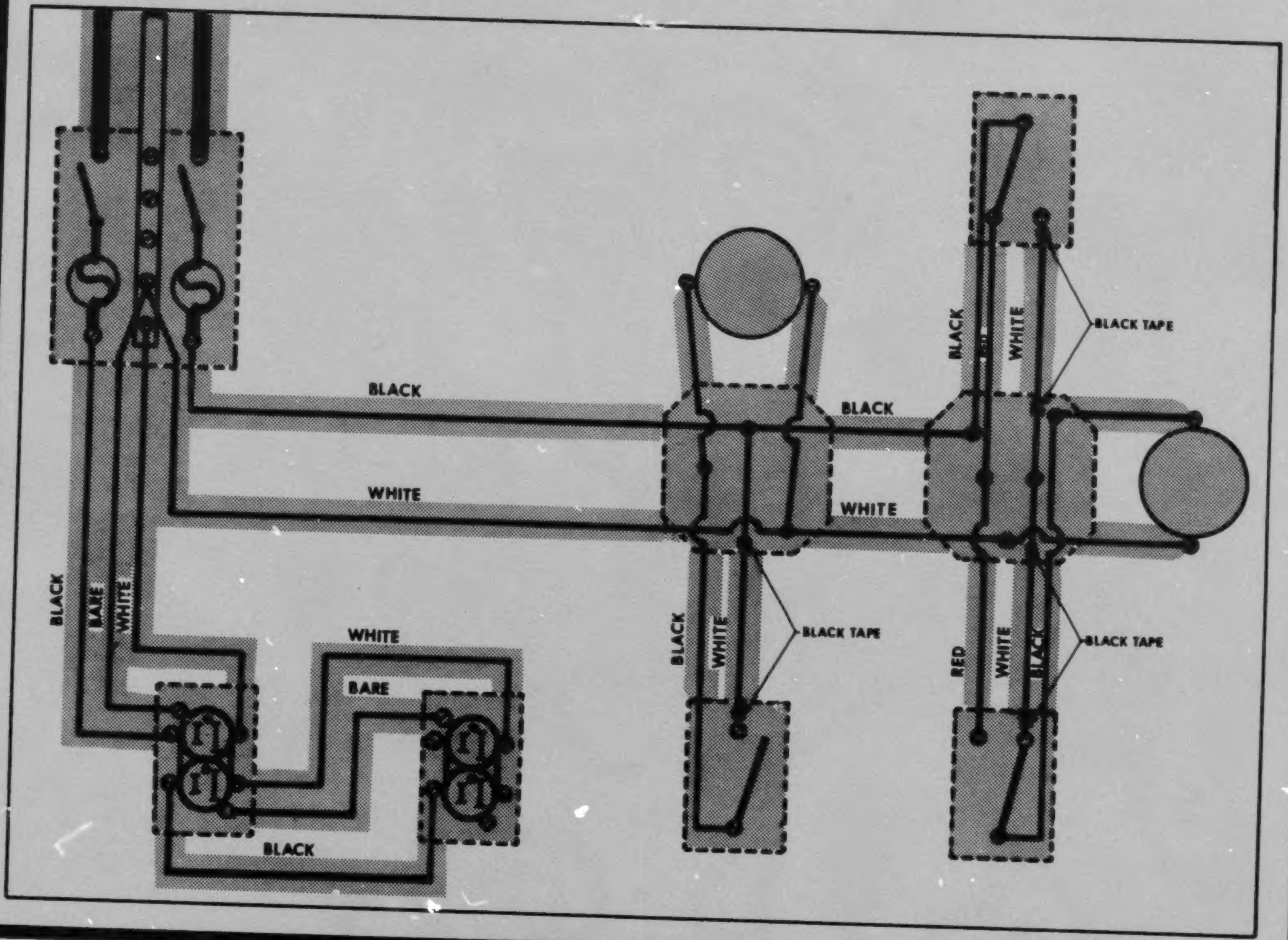
INSTALLED IN TWO TRAVELER WIRES OF THE THREE-WAY SWITCHES

WIRING LAYOUT



WIRING DEMONSTRATION BOARD

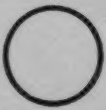
WIRING LAYOUT

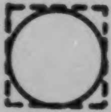

BLACK
BLACK
WHITE
WHITE
BLACK
WHITE
BLACK TAPE
BLACK
BARE
WHITE
WHITE
BARE
BLACK
BLACK
WHITE
BLACK TAPE
RED
WHITE
BLACK
BLACK TAPE

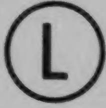
Gen. Ag. Mech.

ELECTRICAL SYMBOLS

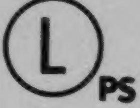
GENERAL OUTLETS


Lighting Outlet

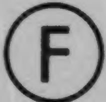

Ceiling Lighting Outlet for Recessed Fixture (Outline Shows Shape of Fixture.)



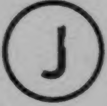
Lighting Outlet with Lamp Holder



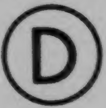
Lighting Outlet with Lamp Holder and Pull Switch



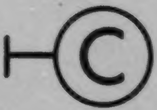
Fan Outlet



Junction Box



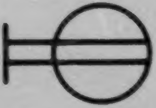
Drop-Cord Equipped Outlet

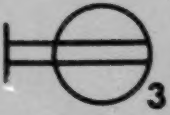


Clock Outlet

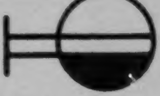
To Indicate Wall Installation of Above Outlets, Place Circle Near Wall and Connect with Line as Shown for Clock Outlet.

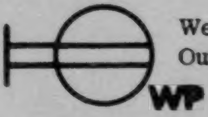
CONVENIENCE OUTLETS


Duplex Convenience Outlet (Grounding Type Outlet Required)

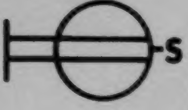


Triplex Convenience Outlet (Substitute Other Numbers for Other Variations in Number of Plug Positions, Such as 1 for Single Convenience Outlet)

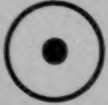

Duplex Convenience Outlet-Split Wired

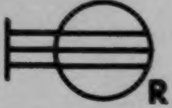


Weatherproof Convenience Outlet

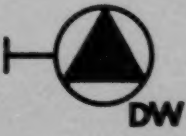


Combination Switch and Convenience Outlet


Floor Outlet



Range Outlet



Special-Purpose Outlet. Use Subscript Letters to Indicate Function. DW-Dishwasher, CD-Clothes Dryer, etc.

SWITCH OUTLETS

S Single-Pole Switch

S_2 Double-Pole Switch

S_3 Three-Way Switch

S_4 Four-Way Switch

S_{WP} Weatherproof Switch

S_D Automatic Door Switch

S_P Switch and Pilot Light

GENERAL AGRICULTURAL MECHANICS

Unit R: Farm and Ranch Electrification

Topic 2: Selection and Maintenance of Electric Motors

Suggested Procedure and Activities: It is suggested that the different types of motors be displayed and used during the presentation of the topic. Demonstrating the use of the continuity test lamp should assist students in understanding the operating principles and installation procedures of electric motors.

1. Advantages of Using Electric Motors

The use of electric power on the farm is steadily increasing. The reasons for this increase are the many advantages offered by electric power:

Transparency No. 1

1. Inexpensive to Operate - An electric motor can work continuously. A 1/4 horsepower (Hp) motor can do the physical work that two men can accomplish. (The cost of operating electric motors may be reviewed.)
2. Always Ready to Work - Temperature extremes and changes have little effect on motor starting or operation.
3. Efficient - Compared to other power sources, the electric motor is one of the most efficient. The efficiency of electric motors will vary from 65 to 90 percent.
4. Long Life - Having few moving parts with little to wear out enables a motor to last many years with proper care.
5. Simple to Operate - No special skills or experience are required to operate electric motors. They can be started and stopped by a simple switch.
6. Safe - Electric motors are safe if properly installed. They require no inflammable fuel and produce no dangerous flames or fumes. They have no open gears and require no physical labor to be started.
7. Minimum Servicing - Electric motors require a minimum of attention - no fuel to carry, no oil to change, or battery to change.
8. Quiet Operation - Operate quietly and smoothly with very little vibration.

9. Compact and Easily Automated - Require little space and can be automatically and remotely controlled.

10. Adaptable - Electric motors are light and can be easily moved. They are adaptable to different operating positions and conditions.

2. Factors to Be Considered in Selecting Electric Motors

A number of factors should be considered when selecting electric motors for a specific job. A list and discussion of these factors are as follows:

Transparency No. 2

1. Type of Power Available - The type of electric service available is important because a 230 volt motor should not be selected if only 115 volt circuits are available. Also, a three-phase motor cannot be operated on an electrical system that has only single-phase service. Most of the common motors discussed here will be single-phase, single voltage (115 volt) or dual voltage (115 or 230 volt) motors.

2. Size of Motor - The size of electric motors is rated in horsepower. The rating given to a motor refers to the power that it will develop when the motor is turning at full speed. The "rules of thumb" used for estimating the size of motor needed are (1) If the equipment can be operated by hand, an 1/4 Hp motor will usually be adequate, and (2) If a gasoline engine is to be replaced by an electric motor, an electric motor approximately 2/3 the Hp rating of the engine will usually be adequate.

3. Starting Load - The motor selected must have the starting torque or turning force to start the load. Various motors have different methods of starting and different starting torques. Based upon the method of starting, there are seven types of motors:

    1. Split-Phase
    2. Capacitor-Start
    3. Split-Capacitor Start
    4. Repulsion Start
    5. Series or Universal
    6. Shaded Pole
    7. Three-Phase

   The characteristics and common uses of these motors will be discussed later in this lesson.

4. Speed Requirement - Electric motors are rated at the speed the shaft will turn in revolutions per minute (rpm) when the motor is operating at full speed. The rpm of the motor should be the speed needed to operate the equipment at the proper speed.

5. Type of Bearings - Electric motors may have sleeve bearings or ball bearings. Motors with ball bearings will normally require less maintenance and can be mounted in any position.

6. Type of Base - The motor may need a rigid base, a sliding base that is adjustable, or a cushion mount to reduce vibration and wear.

7. Environment - The type of motor enclosure (frame) should be selected to provide proper protection to the motor from its surroundings - primarily protection from dust, dirt, and water. The three common types of enclosures available are (1) Open-Dripproof, (2) Splashproof, and (3) Totally Enclosed.

3. Nameplate on an Electric Motor

The nameplate on an electric motor provides information that will assist a person in selecting the proper motor for the job, in making the installation, and in energizing the motor with the proper voltage. An explanation of each part of the nameplate is given below:

Transparency No. 3

A.C. - 1 PH. - This indicates the motor will operate on alternating current and single phase power.

Motor Type - This refers to the model or motor type as designated by the manufacturer.

Thermoguard Type - The motor has a built-in protection device to protect it from too many amperes. The thermal relay opens the circuit when the ampere flow becomes high enough to endanger the motor windings. The thermal relay may close automatically after it cools, or it may be the manual-reset type that requires an operator to push the reset button each time the thermal relay opens.

HP-1/2 - The motor is rated at 1/2 horsepower.

R.P.M. - 1725 - The motor shaft turns 1725 rpm when pulling its rated load.

Cycle - 60 - The motor is to be used on 60 cycle current.

^{o}C - 40 - This indicates the temperature rise in the windings when the motor operates at rated load and voltage under normal conditions.

Hours - Cont. - This motor is designed to operate continuously, while some are designed to operate intermittently.

Volts - Amps - The voltage on which the motor will operate is designated. If it is a single-voltage motor, only one voltage rating will be designated. A dual-voltage motor will have both voltages shown, as in the illustration. The numberof amperes is shown under each voltage and is to be considered the ampere rating of the motor at its rated load. Note that the ampere rating at 240 volts is exactly one-half the ampere rating when wired with 120 volts. Smaller conductors may be used for motors operating on 240 volts because only one-half the amperes are carried on each wire.

The proper wiring diagram of the terminal block should be followed for the voltage to be used.

This motor can be reversed (rotate shaft in opposite direction) by interchanging the red and yellow leads on the terminal block. Other motors may be reversed by other methods which will be discussed later. Some motors may not be reversed.

Open - This indicates the conditions under which the motor can be operated. The "open" frame designation means that the motor should not be used in a wet or dusty environment.

Some of the nameplate information is not discussed here because it is for the manufacturer's use or it will be discussed later in this lesson.

4. Types and Uses of Common Electric Motors

There are six different types of common electic motors. The motor selected will depend upon how it is to be used. A discussion of the types and uses is given below:

Transparency No. 4

Split-Phase Motor - The characteristics are as follows:

1. This is used for loads that are easy to start.
2. This type has a high starting current requirement and will draw 6 to 8 times its normal running current when starting.
3. The sizes normally available are from 1/20 Hp to 1/3 Hp and may be obtained in 1/2 Hp and 3/4 Hp sizes.
4. It is considered a constant speed motor and is single voltage, except in the 1/2 Hp and 3/4 Hp sizes.
5. This is one of the least expensive motors and is of simple construction.
6. It has a starting winding, starting switch, and a running winding.
7. This type has many applications for easy starting loads. Examples are emery wheel, bench saw, washing machine, and seed cleaner.

Transparency No. 5

The wiring diagram for a single voltage, split-phase motor is illustrated in the above transparency. Note the starting switch is in the starting winding. The starting switch is closed when the motor is at rest. As the motor reaches about 80% of its running speed, the starting switch opens. This stops the flow of current through the starting winding.

One end of the starting and running windings are placed together for one lead and the other ends of both windings are placed together for the other lead.

To reverse the rotation of the shaft, the ends of the starting windings are changed with respect to the running winding leads.

Transparency No. 6

Each of the windings in a motor may be identified by the use of the continuity test lamp illustrated in this transparency. To provide students with practice in testing windings, they should make a continuity test lamp and power lead.

If the leads of the continuity test lamp are connected to the ends of different windings, the light will not burn when plugged into an outlet. The winding being tested must complete the circuit in order for the light to burn.

When power leads are connected to the ends of the running winding, the motor will hum. The shaft can be turned either direction by hand and the motor will run.

When power leads are connected to the ends of the starting winding, the motor will start and stop as the centrifugal mechanism closes and opens the starting switch.

Transparency No. 7

Capacitor-Start Motor - As the name indicates, this motor has a capacitor in the starting winding to give the motor more starting force. It is used for loads that are fairly difficult to start. Other aspects of this type are given below:

1. It has medium starting current requirement and will draw 3 to 6 times its normal running current when starting.
2. It is considered a constant speed motor.
3. The sizes normally available are from 1/6 to 5 Hp.
4. Capacitor-start motors are usually more expensive than split-phase motors.
5. They may be obtained as a single voltage or dual-voltage motor.

6. Single voltage motors have a starting winding and one running winding. Dual voltage motors have a starting winding and two running windings.
7. It has many applications for more difficult starting loads. Examples are air compressors, pumps, blowers, feed grinders, conveyors, and power tools.

Transparency No. 8

The wiring diagram for a capacitor-start, single voltage motor is illustrated here. Note the capacitor and starting switch in the starting winding.

The windings on a capacitor-start, dual voltage motor may be identified with the continuity test lamp as was discussed for the split-phase motor.

Transparency No. 9

The wiring diagrams for a capacitor-start, dual voltage motor, when operating on 120 volts, are shown in this transparency. The running windings are wired in parallel.

Transparency No. 10

The wiring diagrams for a capacitor-start, dual voltage motor, when operating on 240 volts, are illustrated here. The running windings are wired in series.

Transparency No. 11

Repulsion-Start Motor - This motor is used for starting heavy loads. The high starting torque is provided by a wound rotor and brushes. Other characteristics are as follows:

1. It has low starting current requirement and will draw 2 to 3 times its normal running current when starting.
2. It is considered a constant speed motor.
3. It is usually available as a dual voltage motor.
4. The sizes normally available are from 1/6 to 20 Hp.
5. It is a heavy duty motor and is more expensive than the split-phase or capacitor-start motor.
6. It has many applications for heavy starting loads. Examples are feed mixers, large blowers, silo unloaders, elevators, compressors, and deep-well pumps.

Transparency No. 12

The wiring diagrams for operating on 120 volts and 240 volts are illustrated in this transparency. For 120-volt operation, the windings are wired in parallel, while the windings on 240-volt are wired in series.

The direction of rotation of the motor shaft may be changed by moving the brush-ring holder position as illustrated.

Transparency No. 13

Universal Motor - This motor is a series motor and can be operated on A.C. or D.C. current, and is designed for intermittent use. It has a short life when compared to the life of the other motors studied. Other aspects of this type are given below:

1. Universal motors are usually small in size, but may be obtained in sizes from 1/20 to 1 Hp.
2. This is a variable speed motor, depending upon the load.
3. This motor has a high starting torque and requires a high starting current.
4. It is normally used for portable tools and portable appliances.

Shaded-Pole Motor - This is a small, single-phase motor that operates on A.C. current. It has a low starting torque and is low in efficiency. It is available in sizes from 1/100 to 1/20 Hp, and is simply constructed. It is used for very light loads such as small fans, blowers, and circulating pumps on evaporative water coolers. The design and windings of the universal and shaded-pole motors are shown in the following transparency.

Transparency No. 14

Three-Phase Motor - This motor is of simple construction and is operated only on three-phase A.C. current. Other factors relative to this type are as follows:

Transparency No. 15

1. It has medium to high starting torque.
2. This motor may be obtained with the designation of low, normal, or high starting current requirement.
3. Its design provides for "self-starting" and includes no starting mechanism.
4. The three-phase motor is a constant speed motor.
5. It is available in sizes from 1/3 to several thousand Hp.
6. It is primarily used on large equipment.
7. The sizes 1 Hp and larger are lower in cost than single-phase motors.

Transparency No. 16

The above illustrations show the wiring diagrams of a three-phase motor. To reverse the direction of rotation, any of the motor leads may be interchanged.

5. Motor Drives

Machinery and equipment driven by electric motors are operated at different speeds. For the machine to operate efficiently, it must be driven at a specified speed; therefore, before selecting an electric motor and the drive, the operating speed of the machine should be determined.

In the selection of a drive, two factors are considered: (1) Operating speed of equipment, and (2) Size of drive. The operating speed of newly purchased equipment should be relatively simple to determine, since an operator's manual generally accompanies the equipment. A nameplate or some other source might provide this information for used equipment.

The size of drive for a machine is not as critical as the operating speed, but the drive should be large enough to pull the load efficiently. Drives may be classified into two general types, which are (1) direct and (2) speed-conversion (bolts and pulleys).

DIRECT DRIVE

A direct drive is a motor connected directly to a machine. The machine operates at the same speed as the motor. There are four kinds of direct drives. These are (1) flexible shaft, (2) flexible hose. (3) cushion-flange coupling, and (4) flange coupling.

Transparency No. 17

Flexible Shaft Drive - This type is particularly useful for equipment that is operated at various angles. Grinders and buffers are examples. Since flexible shafts are manufactured to operate in only one direction, the direction the shaft is to be operated (clockwise or counter clockwise) should be specified when a shaft is purchased. The machine with this type is operated at the same speed as is the motor.

Flexible Hose Coupling Drive - A piece of plastic or rubber hose can be used as the drive. The ends of the hose are forced over the ends of the machine and motor shaft and are held in place with clamps.

Cushion-Flange Coupling Drive - This type consists of two flanges, which are attached to the shafts, and a flexible center part, which is fastened to the flanges. A flexible action is furnished by the center part which is made of rubber or a similar material.

Flange Coupling Drive - Two metal discs and a flexible middle disc are components of this type. The metal discs are fastened to the motor and machine shafts, and the middle disc is placed between the metal discs. The parts are then fastened together.

SPEED-CONVERSION DRIVES

Transparency No. 18

These are used to drive equipment and machines at a speed which is different from that of the motor furnishing the power. The three types of speed conversion drives are (1) pulley and belts, (2) gear, and (3) chain-and-sprocket.

Since the gear and chain-and-sprocket drives are generally included as a part of the machine to be driven and are very complex, and since the pulley-and-belt drive is most often used on the farm, it is the only one discussed.

PULLEY-AND-BELT DRIVE

The pulley is a very important part of the driven system. Generally, the larger the pulley, the better, because less slippage occurs when more pulley area is in contact with the belt.

To prevent slippage, a pulley at least two inches in diameter should be used on motors of 1/2 Hp or less. If belt slippage will not affect the operation of equipment, a smaller diameter pulley may be used. For motors larger than 1/2 Hp, a three-inch diameter pulley is recommended.

A jack shaft (shaft with a pulley on both ends) is recommended as a part of the drive for equipment designed to operate on less than 200 rpm. It is recommended that the pulley connecting the jack shaft to the motor be 12 inches in diameter.

The four types of pulley-and-belt drives are (1) V-belt, (2) webbed multi-V-belt, (3) flat-belt, and (4) V-flat drive. A discussion of each type follows:

V-Belt Drive - This is the most popular drive used with electric motors. It has several advantages: The motor may be mounted on or close to the machine, and less tension is needed on the belt because of the wedging action of the belt and the pulley groove. Also, the belt stays on the pulley better.

Transparency No. 19

Three sizes of V-belts are normally used on farms. These are the fractional-horsepower (FHP), A-section, and B-section.

The FHP is suited for pulleys 2 1/2 inches and less in diameter. They are thinner and much more flexible.

The A-section V-belt is heavier and can be used on small pulleys, but there is more slippage than the thinner belt. The stiffness of the belt prevents it from following the curvature of the pulleys. It is designed for pulleys three inches in diameter or larger.

B-section V-belts are designed for use on motors of 3 Hp or larger. The motor pulley should be 5 1/2 inches or larger in diameter.

Number and Types of V-Belts Recommended for 1750 RPM Motors

Diameter of Motor Pulley in Inches	Size of Motor							
	Horsepower							
	½ or Smaller	3/4	1	1½	2	3	5	7½
2	FHP*	FHP*						
3	1-A	1-A	1-A	2-A	2-A	3-A	5-A	8-A
4	1-A	1-A	1-A	1-A	2-A	2-A	3-A	5-A
5	1-A	1-A	1-A	1-A	1-A	2-A	3-A	4-A
6	1-A	1-A	1-A	1-A	1-A	1-B	2-B	2-B
7	1-A	1-A	1-A	1-A	1-A	1-B	2-B**	2-B
8	1-A	1-A	1-A	1-A	1-A	1-B**	1-B	2-B

*FHP-(Fractional Horsepower) a belt designed for small pulleys and small motors. Most commonly available in 3/8 inch width but also available in 1/2 and 5/8 widths.
**The same number of Type A belts could be used instead of Type B. On multiple belt drives, all belts should be replaced at one time.

Many of the farm motors are fractional-horsepower and require only a single V-belt to drive the machine. Three types of V-pulleys are available. These are the standard V-, V-step-, and adjustable V-pulleys. The standard V-pulley is used when only one speed is needed, while the V-step pulley is used for machine driven variable speeds, such as would be used on a drillpress. The adjustable V-pulley is also for variable speeds. The diameter of the pulley may be increased or decreased to adjust the speed to the desired rpm.

To determine the length of a V-belt for a mounted motor, a piece of string is looped around and in the grooves of the pulleys, pulled tight, and a knot tied in ends of the string. The string is cut, and its length is measured. This gives the inside length of the belt needed.

The following procedure may be used to determine the size of belt to use for an unmounted motor:

4 x diameter of largest pulley ________
1.6 x diameter of motor pulley ________
1.6 x diameter of machine pulley ________
Total length ________

Example: Motor pulley 3 inches, machine pulley 6 inches

4 x 6 = 24.0 inches
1.6 x 3 = 4.8 inches
1.6 x 6 = 9.6 inches
Total 38.4

The closest standard length belt to the above measurement should be purchased, and the motor should be mounted at a distance from the machine shaft to provide adequate tension on the belt.

Webbed Multi-V-Belt - Two or more V-belts webbed together make up this type. Its main advantages are the elimination of slippage and belt turnover.

Flat-Belt - The flat drive consists of a flat pulley on the motor, as well as one on the machine being driven. This is used for motors located some distance from the machine. A feed grinder is an example. A pressed-paper pulley should be used for high speeds, while steel, wood, or cast iron pulleys may be used for slow speeds. The most popular flat belts for farm use are made of rubber.

V-Flat Belt Drive - This type consists of one or more V-belts, one V-pulley, and one flat pulley. This system is recommended for machines with pulleys larger than 12 inches in diameter and operated at 600 rpm or less. The distance from the center of the motor pulley to the center of the machine pulley should not be greater than the diameter of the equipment pulley. Following this recommendation will prevent belt slippage.

Determining the Proper Size Pulley to Use - The following formula is used to determine the proper pulley size for an inline motor and machine:

> (rpm of motor) x (Diameter of motor pulley) = (rpm of machine) x (Diameter of machine pulley).

In the following example, the size of pulley needed to turn a fan at 875 rpm is determined. The fan is driven by a 1/3 Hp electric motor which operates at 1750 rpm and has a pulley two inches in diameter.

Step No. 1 - 1750 x 2 = 875 x Dia. Machine Pulley

Step No. 2 - $D = \frac{1750 \times 2}{875}$ = 4 inches - pulley diameter needed on machine

The following is the procedure to use to determine the diameter of pulleys needed on a motor, jack shaft, and machine when this drive system is used.

In the following example, it is assumed that the machine should operate at 60 rpm and the motor speed is 1750 rpm.

Previous recommendations were that a two-inch pulley be used on fractional-horsepower motors and that the jack shaft have one pulley 12 inches in diameter.

Step No. 1 - Calculate speed of jack shaft. The following formula is used:
rpm (motor) x D (motor pulley) = rpm (jack shaft) x D (jack shaft pulley)
1750 x 2 = rpm (jack shaft) x 12
rpm (jack shaft) = $\frac{1750 \times 2}{12}$ = 292 rpm

Step No. 2 - Determine size of pulley for machine
292 rpm x diameter (other jack shaft pulley) = 60 rpm x D (machine).
A two-inch pulley is tried for the other jack shaft pulley 292 rpm x 2 in. = 60 rpm x D (machine pulley) Diameter of machine pulley = $\frac{292 \times 2}{60}$ = 9.8 or 10 inch pulley is needed for machine.

6. Motor Protection and Maintenance

Transparency No. 20

Overload Protection - An electric motor should be protected from performing more work than it is designed to perform. If the motor is overloaded, the ampere flow is likely to become great enough to damage the motor.

An overload can be caused by (1) motor size too small for the job, (2) improper wiring and low voltage, (3) improper installation, (4) belts too tight, (5) improper lubrication, or (6) the entry of foreign materials (dust, water, or oil) into the motor.

Overhead protection may be provided by (1) proper fusing of the motor circuit, (2) built in protection in the motor, (3) manual reset switch control, or (4) special motor starter (current-limiting starter). The proper fusing of the motor circuit is discussed in the topic on electric wiring.

Transparencies Nos. 21a and 21b

Proper Installation - The installation of an electric motor should be made so that a minimum of vibration will occur. It is also very important to make the installation so that proper alignment will result. Misalignment will cause wear and may also be a factor in overloading a motor.

Transparency No. 22

Prevent Friction - A minimum of friction in the mechanical operation of a motor is necessary to prevent excessive wear and possible overloading of the motor. The manufacturer's recommendations for lubrication intervals should be closely followed. A high-quality lubricant should be used for motor lubrication. Motors with sleeve bearings require mounting so that the shaft is horizontal and level for proper lubrication.

Worn bearings should be replaced and the alignment of motor, drive, and equipment should be true.

Transparency No. 23

Protect From Dust - The accumulation of dust in and on a motor acts as insulation and may cause excessive heating of the motor. Dust and other foreign materials counteract lubrication and will cause friction and wear in the bearings and shaft.

The dust should be wiped from motors at regular intervals. Air under pressure (not more than 40 pounds per square inch pressure) should be used to blow dust from the windings at regular intervals. Excessive lubrication should be avoided to prevent excessive accumulation of dust. Dust seals and oil caps on motors should be in good condition and kept closed.

Transparency No. 24

Protect From Moisture - Moisture is a conductor of electricity. Dry insulation confines the current to the correct path. When insulation is wet, the current may not be properly confined and a "short" may result. Motors may be protected from moisture by well-ventilated enclosures. A wet motor should be dried thoroughly before it is used. Some type of heat and a fan may be applied to the motor to dry it thoroughly.

Transparency No. 25

Protect From Excessive Oil - Too much oil or grease can be harmful to an electric motor. Damage from too much oil may result from the accumulation of extra dust or from the deterioration of insulation within the motor. The manufacturer's recommendations for lubricating a motor should be closely followed. To remove excessive oil, a non-inflammable solvent and a paint brush may be used.

7. Checking and Cleaning Electric Motors

Disassembly of Split-Phase Motor - The steps to follow are listed below:

1. Mark the end plates and frame with a center punch or other marking device to insure the proper reassembly of the motor.
2. Remove the through bolts or screws and remove the end plate. (A light tap may be needed to loosen the end plate.)
3. Remove the rotor (center shaft).
4. Notice the wiring connections on the terminal wiring plate and the starting switch.
5. Identify the following parts:

Transparency No. 26

1. Motor base
2. End plates
3. Bearings
4. Rotor
5. Fan
6. Centrifugal mechanism
7. Starting switch
8. Oil or grease rings
9. Stator windings
10. Protective device

Cleaning and Checking Split-Phase Motor - The procedure is as follows:

1. Clean motor and motor parts, using a non-inflammable cleaning solvent and paint brush.
2. Disconnect the wiring leads from the terminal wiring plate. Use a continuity test lamp to determine which two leads complete a circuit in the stator windings. Two separate windings should be identified - a running winding and a starting winding. (The running winding will be a heavier wire than the starting winding wire.)
3. Check each winding for a "short" by connecting one lead of the continuity test lamp to one end of a winding. With the continuity test lamp energized, touch the other lead of the lamp to the motor frame. If the light burns, it indicates a "short" between the winding and the metal frame. Test the other winding in the same manner. If a short is indicated, the motor should be rewound or replaced.

Reassembly of Split-Phase Motor - Steps for checking and cleaning are provided below:

1. Connect wiring leads to the proper terminals on the terminal wiring plate.
2. Replace rotor.
3. Replace end plate, being careful to replace it in its original position. (The center punch marks were made for this purpose.)
4. Replace through bolts and tighten evenly. Determine that the rotor turns freely after the through bolts have been tightened.

5. Energize the motor and check its operation.

References:

1. "Electric Motor Lesson Plans for Production Agriculture", Texas Education Agency and Vocational Instructional Services, Texas A&M University, College Station, Texas, 1973

2. "Electric Motors - Selection, Protection, and Drives", American Association for Vocational Instructional Materials, Engineering Center, Athens, Georgia, 1974

3. "V.A. III Agricultural Mechanics", Vocational Instructional Services, Texas A&M University, College Station, Texas, 1972

ADVANTAGES OF ELECTRIC MOTORS

1. INEXPENSIVE TO OPERATE
2. ALWAYS READY TO WORK
3. HIGHLY EFFICIENT
4. LONG LIFE
5. SIMPLE TO OPERATE
6. SAFE
7. MINIMUM SERVICING
8. QUIET OPERATION
9. COMPACT AND AUTOMATICALLY CONTROLLED
10. ADAPTABLE

FACTORS IN SELECTING ELECTRIC MOTORS

TYPE OF POWER AVAILABLE

SIZE OF MOTOR (HORSEPOWER)

STARTING LOAD REQUIREMENT

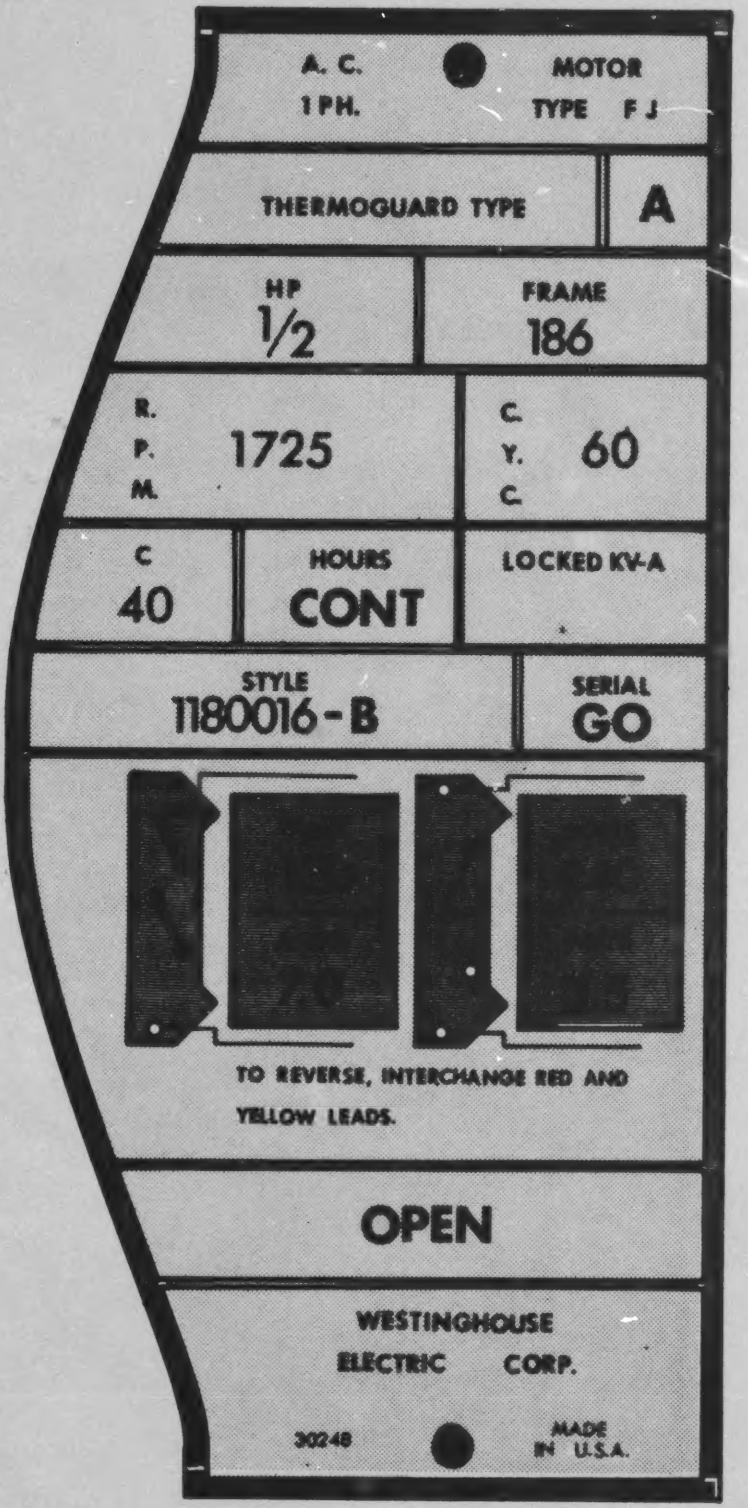
SPEED REQUIREMENT

TYPE OF BEARINGS

TYPE OF BASE OR MOUNT

ENVIRONMENT

MOTOR NAME PLATE



A. C.
1 PH.
MOTOR
TYPE F J
THERMOGUARD TYPE A
HP 1/2
FRAME 186
R. P. M. 1725
C. Y. C. 60
C 40
HOURS CONT
LOCKED KV-A
STYLE 1180016-B
SERIAL GO

TO REVERSE, INTERCHANGE RED AND YELLOW LEADS.

OPEN

WESTINGHOUSE
ELECTRIC CORP.
30248
MADE IN U.S.A.

SPLIT-PHASE MOTOR

FOR EASY STARTING LOADS

HIGH STARTING CURRENT—
6-8 TIMES FULL LOAD CURRENT

SIZES AVAILABLE—
1/20 HP TO 1/3 HP

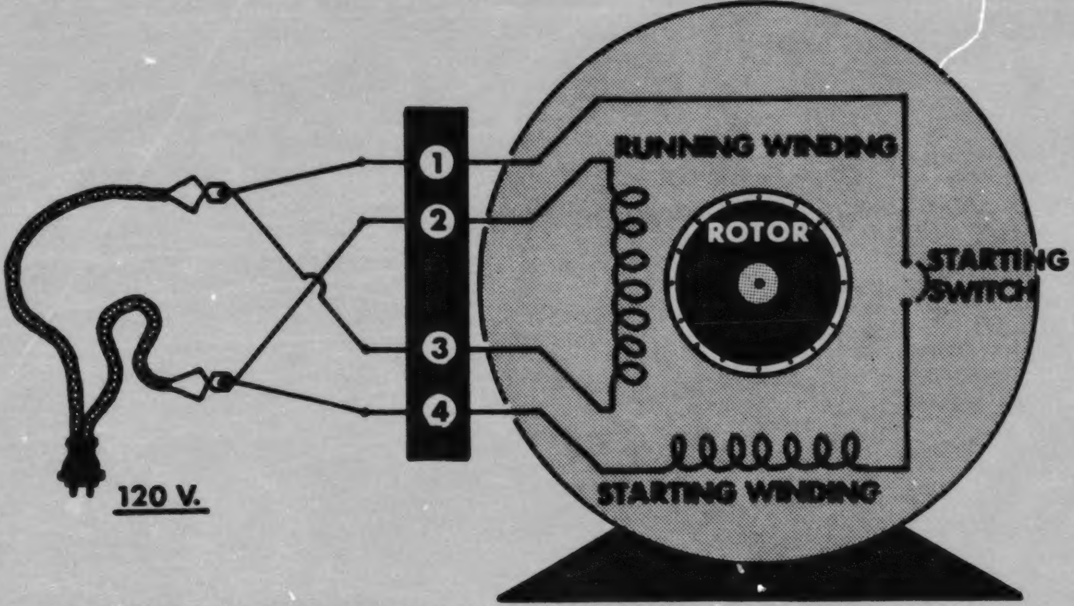
CONSTANT SPEED—
SINGLE VOLTAGE

INEXPENSIVE—
SIMPLE CONSTRUCTION

HAS STARTING WINDING &
STARTING SWITCH

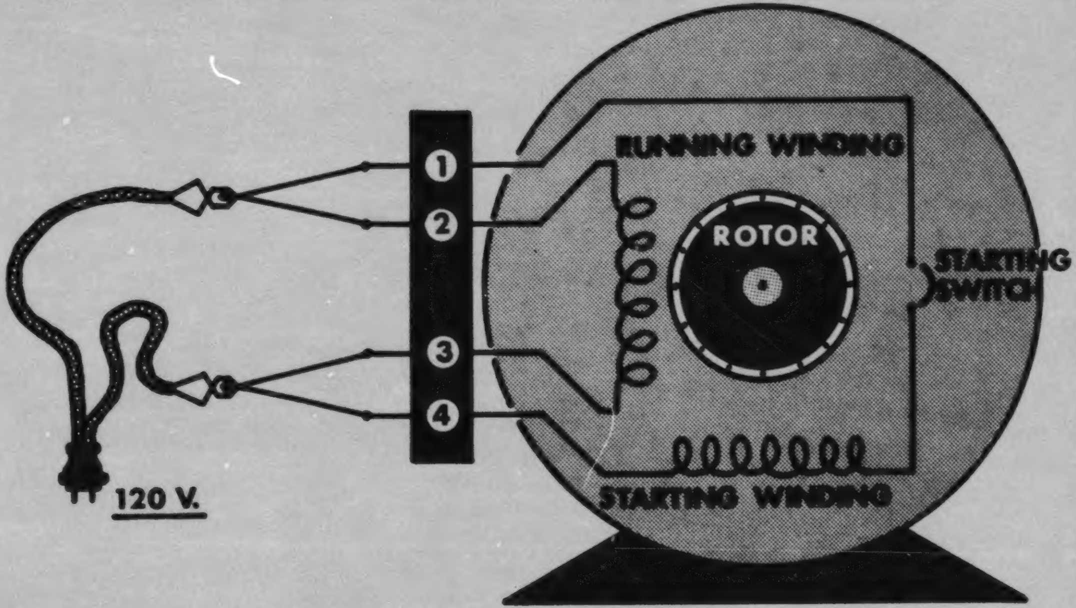
APPLICATIONS--
EMERY WHEEL - SEED CLEANER
BENCH SAW-WASHING MACHINE

SPLIT-PHASE



RUNNING WINDING
1
2
3
4
ROTOR
STARTING SWITCH
STARTING WINDING
120 V.

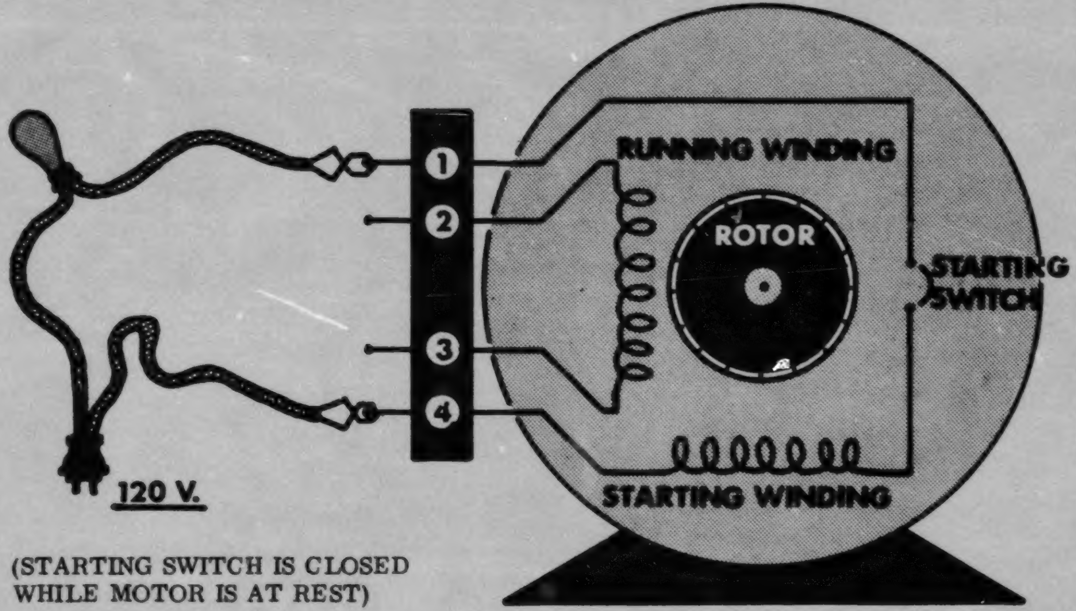
CIRCUIT DIAGRAM FOR A SPLIT-PHASE SINGLE-VOLTAGE MOTOR OPERATING IN ONE DIRECTION.



RUNNING WINDING
1
2
3
4
ROTOR
STARTING SWITCH
STARTING WINDING
120 V.

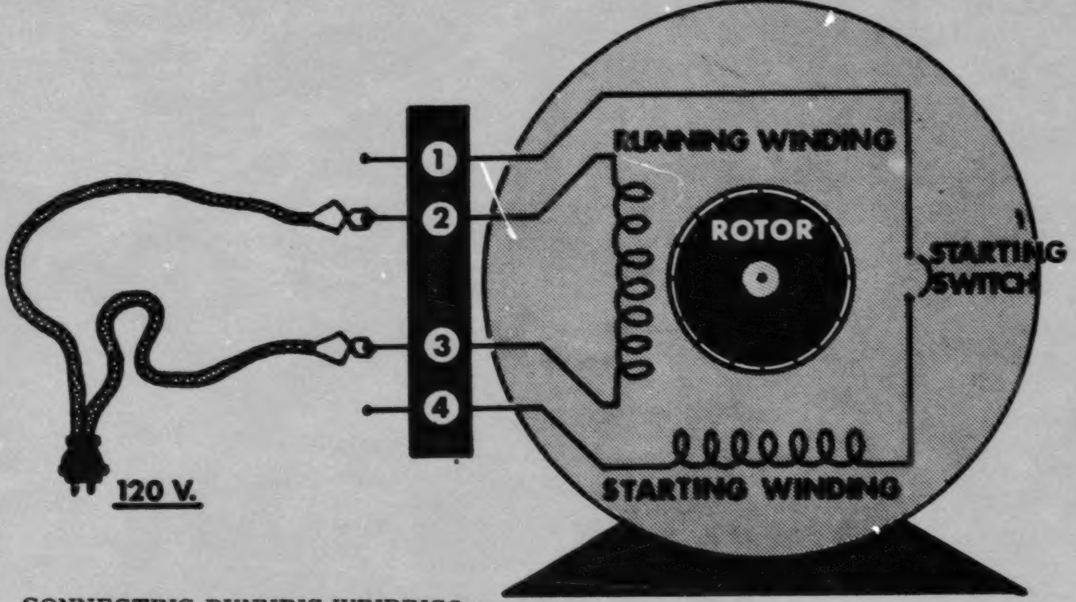
CIRCUIT DIAGRAM FOR A SPLIT-PHASE SINGLE-VOLTAGE MOTOR OPERATING IN OPPOSITE DIRECTION.

TESTING WINDINGS


RUNNING WINDING
1
2
3
4
ROTOR
STARTING SWITCH
STARTING WINDING
120 V.

(STARTING SWITCH IS CLOSED WHILE MOTOR IS AT REST)

TESTING STARTING AND RUNNING WINDINGS ON A SPLIT-PHASE SINGLE-VOLTAGE MOTOR. TEST STARTING WINDING AS SHOWN. TEST RUNNING WINDING BY ATTACHING TEST LEADS TO #2 AND #3.


RUNNING WINDING
1
2
3
4
ROTOR
STARTING SWITCH
STARTING WINDING
120 V.

CONNECTING RUNNING WINDINGS TO POWER LEADS ON A SPLIT-PHASE SINGLE-VOLTAGE MOTOR.

CAPACITY-START MOTOR

HAS A CAPACITOR IN THE STARTING WINDING

USED FOR DIFFICULT STARTING LOADS

MEDIUM STARTING CURRENT—3-6 TIMES FULL LOAD CURRENT

CONSTANT SPEED

SIZES—1/6 HP TO 5 HP

25-40% MORE EXPENSIVE THAN SPLIT-PHASE MOTORS

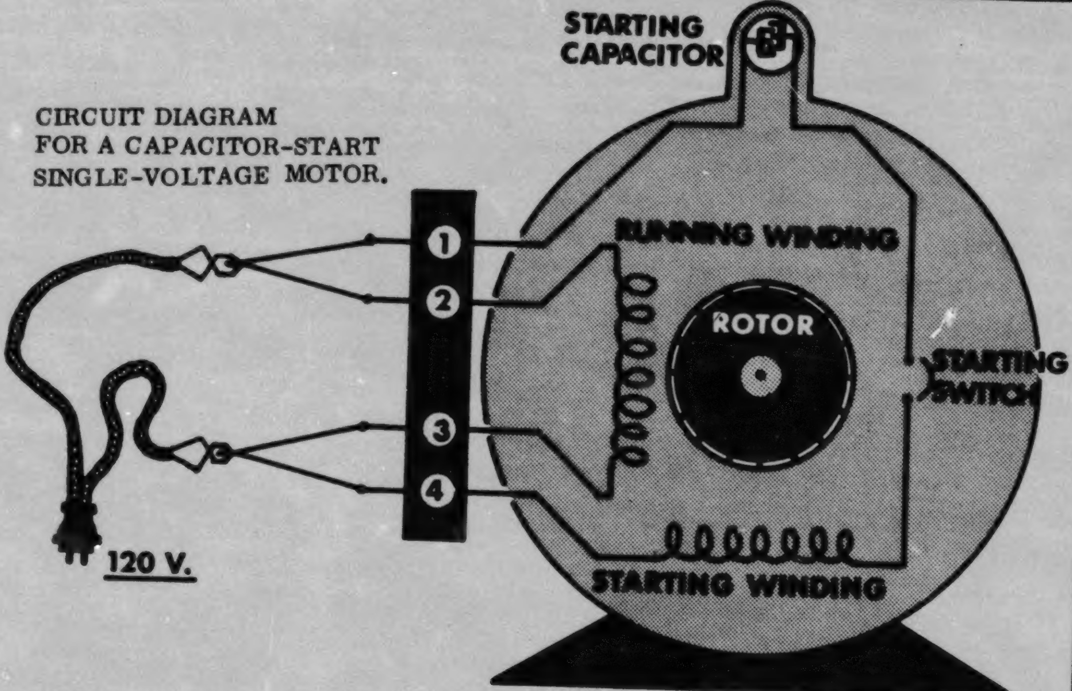
SINGLE OR DUAL VOLTAGE— 120/240 VOLTS

HEAVY DUTY APPLICATIONS--

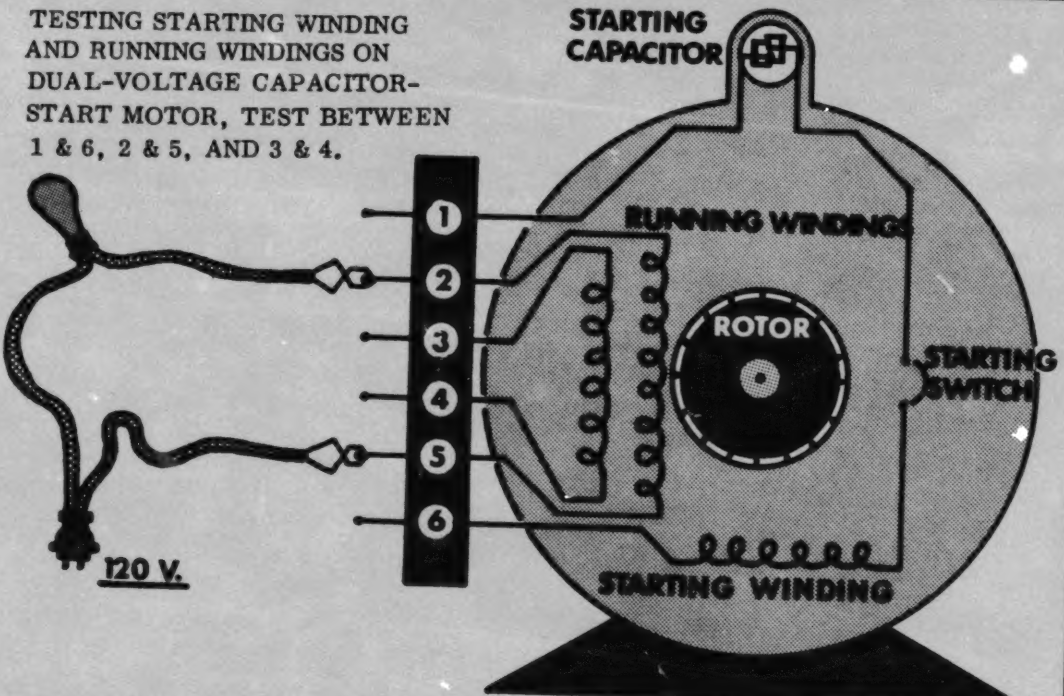
AIR COMPRESSORS
FEED GRINDERS
POWER TOOLS
PUMPS
BLOWERS
CONVEYORS

CAPACITOR-START

CIRCUIT DIAGRAM FOR A CAPACITOR-START SINGLE-VOLTAGE MOTOR.

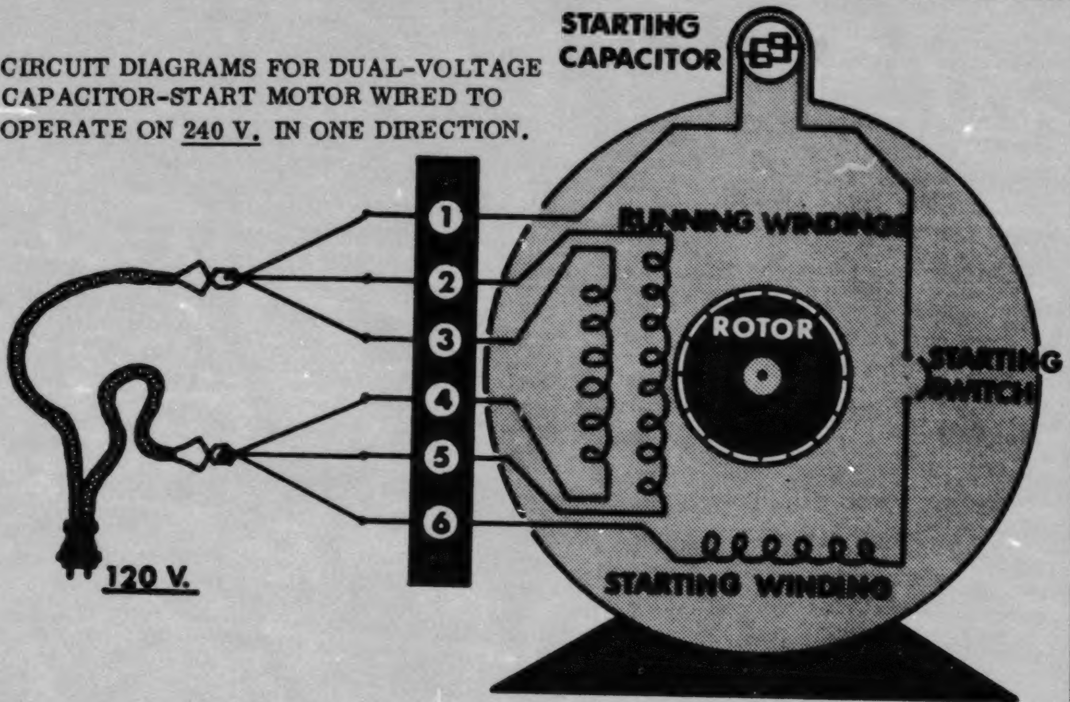

STARTING CAPACITOR
RUNNING WINDING
ROTOR
STARTING SWITCH
STARTING WINDING
1
2
3
4
120 V.

TESTING STARTING WINDING AND RUNNING WINDINGS ON DUAL-VOLTAGE CAPACITOR-START MOTOR, TEST BETWEEN 1 & 6, 2 & 5, AND 3 & 4.

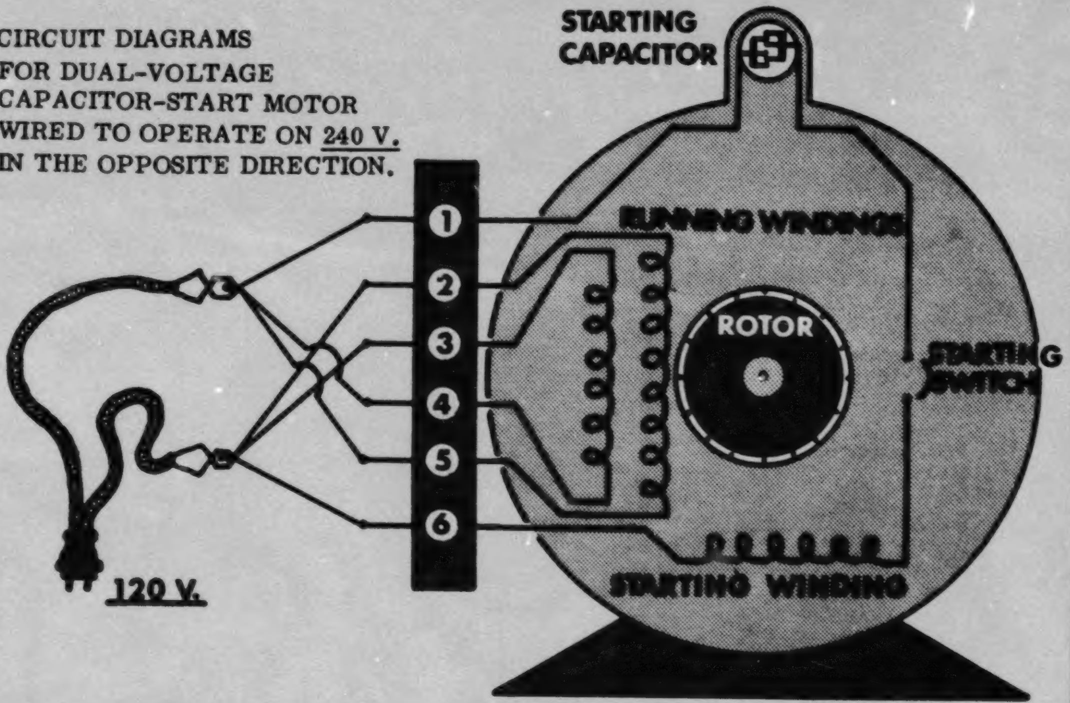

STARTING CAPACITOR
RUNNING WINDINGS
ROTOR
STARTING SWITCH
STARTING WINDING
1
2
3
4
5
6
120 V.

CAPACITOR-START DUAL VOLTAGE

CIRCUIT DIAGRAMS FOR DUAL-VOLTAGE CAPACITOR-START MOTOR WIRED TO OPERATE ON 240 V. IN ONE DIRECTION.

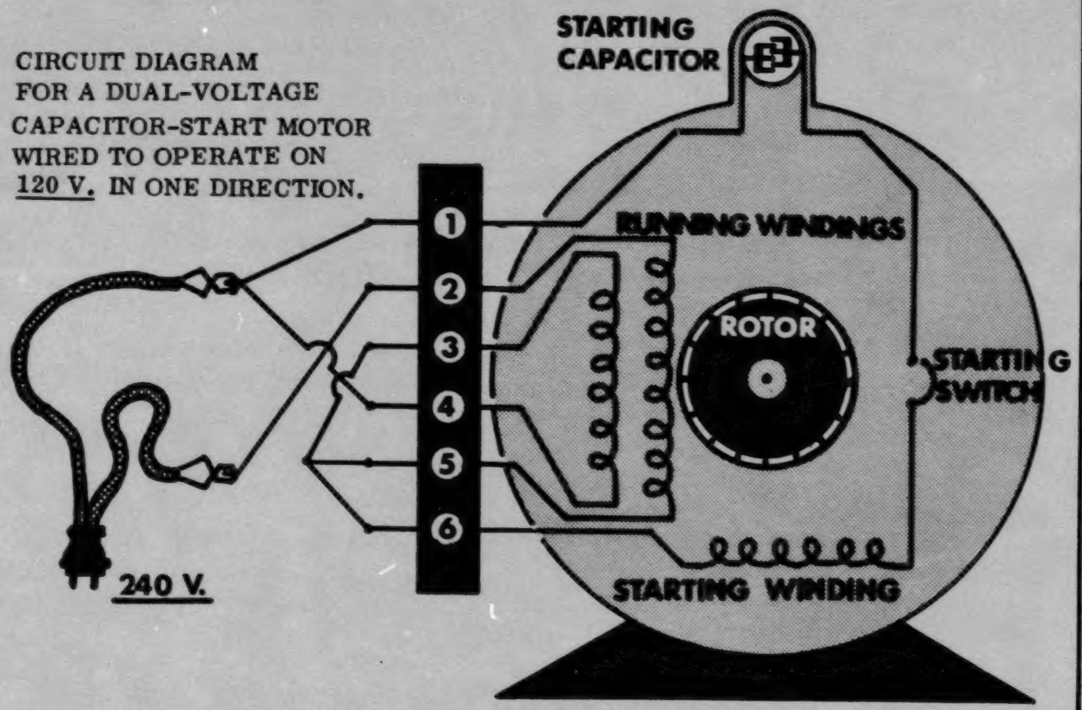

STARTING CAPACITOR
1
2
3
4
5
6
RUNNING WINDINGS
ROTOR
STARTING SWITCH
STARTING WINDING
120 V.

CIRCUIT DIAGRAMS FOR DUAL-VOLTAGE CAPACITOR-START MOTOR WIRED TO OPERATE ON 240 V. IN THE OPPOSITE DIRECTION.

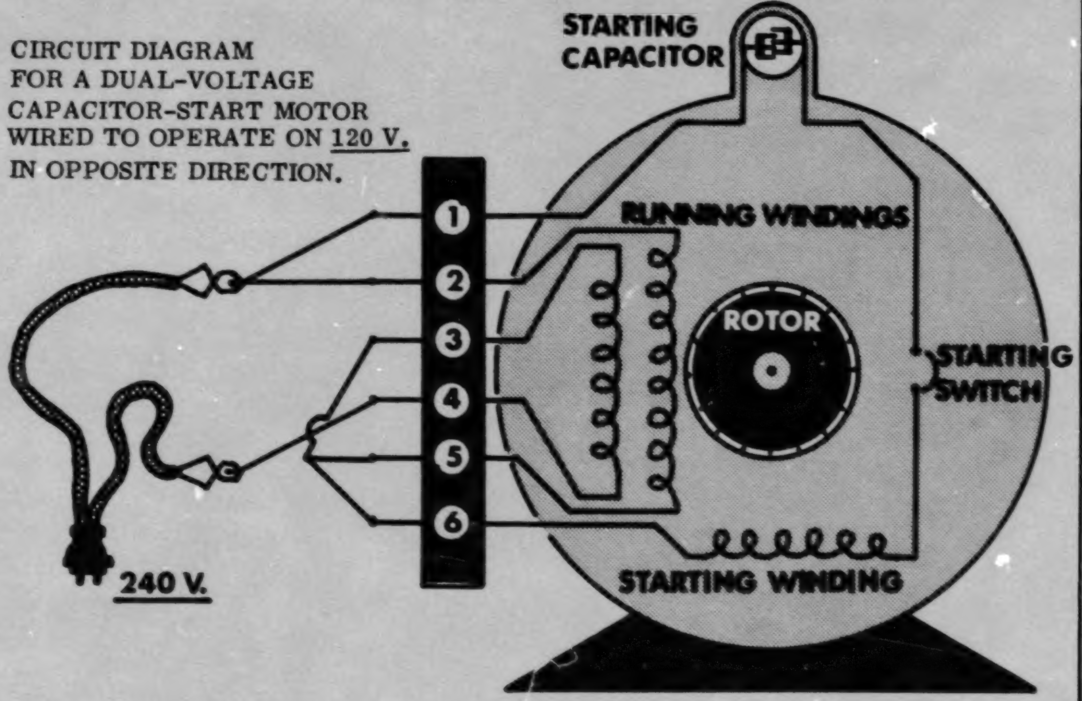

STARTING CAPACITOR
1
2
3
4
5
6
RUNNING WINDINGS
ROTOR
STARTING SWITCH
STARTING WINDING
120 V.

CAPACITOR-START DUAL VOLTAGE

CIRCUIT DIAGRAM
FOR A DUAL-VOLTAGE
CAPACITOR-START MOTOR
WIRED TO OPERATE ON
120 V. IN ONE DIRECTION.


STARTING CAPACITOR
RUNNING WINDINGS
ROTOR
STARTING SWITCH
STARTING WINDING
1
2
3
4
5
6
240 V.

CIRCUIT DIAGRAM
FOR A DUAL-VOLTAGE
CAPACITOR-START MOTOR
WIRED TO OPERATE ON 120 V.
IN OPPOSITE DIRECTION.


STARTING CAPACITOR
RUNNING WINDINGS
ROTOR
STARTING SWITCH
STARTING WINDING
1
2
3
4
5
6
240 V.

REPULSION-START MOTOR

USED FOR HEAVY STARTING LOADS

USES WOUND ROTOR AND BRUSHES FOR STARTING

HIGH STARTING TORQUE- LOW STARTING CURRENT—2-3 TIMES FULL LOAD CURRENT

CONSTANT SPEED

USUALLY DUAL VOLTAGE- 120/240 VOLTS

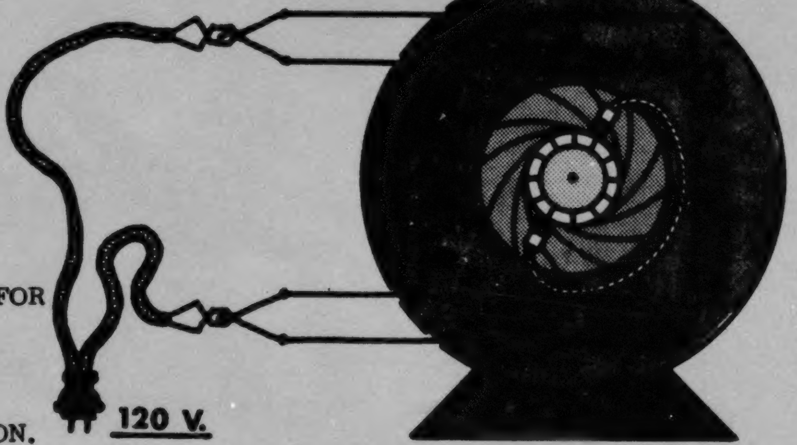
SIZES—1/6 HP TO 20 HP

HEAVY DUTY—MORE EXPENSIVE TYPE MOTOR

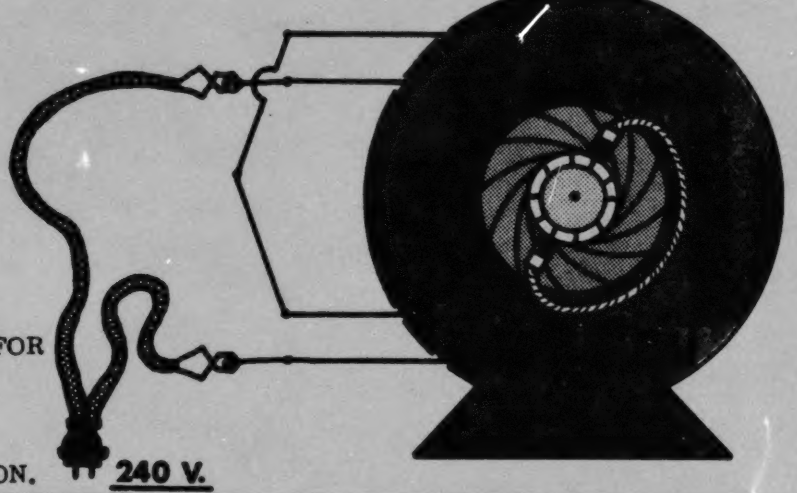
APPLICATIONS- -

LARGE BLOWERS	COMPRESSORS
SILO UNLOADERS	FEED MILLS
DEEP WELL PUMPS	ELEVATORS

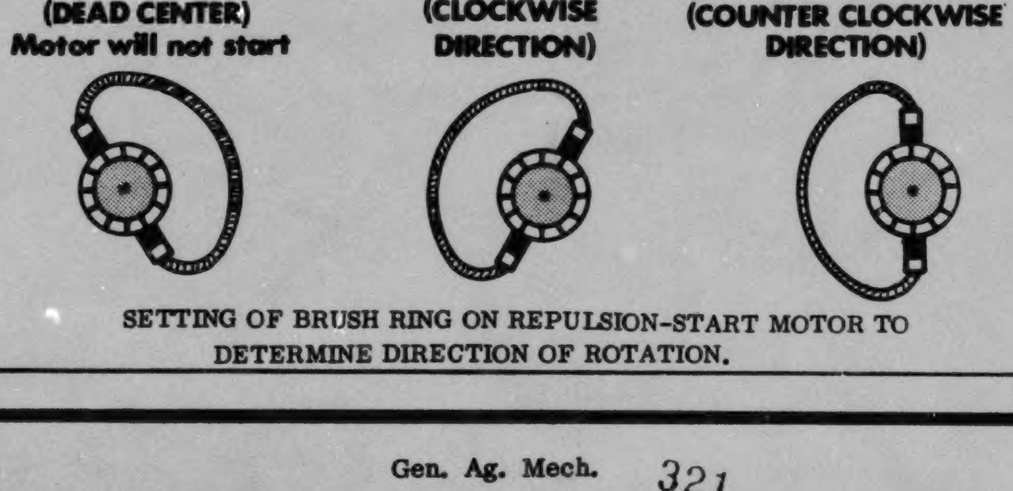
REPULSION-START



CIRCUIT DIAGRAM FOR A DUAL-VOLTAGE REPULSION-START MOTOR WIRED FOR 120V OPERATION.



CIRCUIT DIAGRAM FOR A DUAL-VOLTAGE REPULSION-START MOTOR WIRED FOR 240V OPERATION.


(DEAD CENTER)
Motor will not start
(CLOCKWISE DIRECTION)
(COUNTER CLOCKWISE DIRECTION)

SETTING OF BRUSH RING ON REPULSION-START MOTOR TO DETERMINE DIRECTION OF ROTATION.

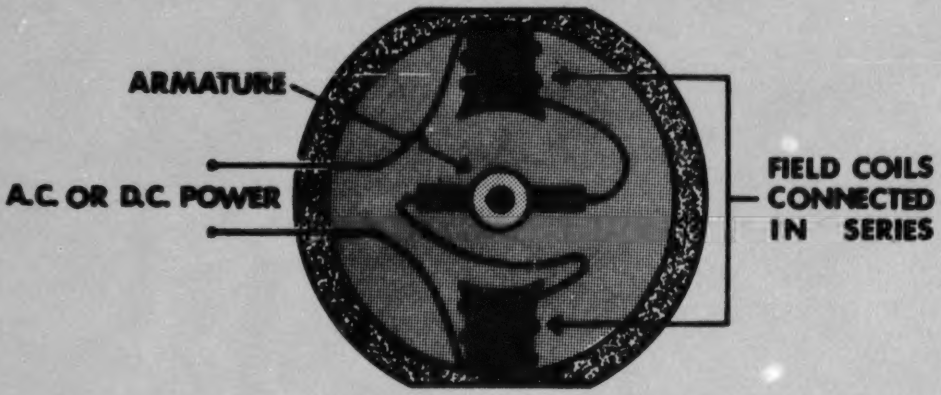
UNIVERSAL MOTOR

1. OPERATES ON AC OR DC
2. SHORT LIFE—INTERMITTENT USE
3. 1/20 TO 1 HORSEPOWER
4. SPEED DEPENDS UPON LOAD
5. HIGH STARTING TORQUE—HIGH STARTING CURRENT
6. USED FOR PORTABLE TOOLS AND APPLIANCES

SHADED-POLE MOTOR

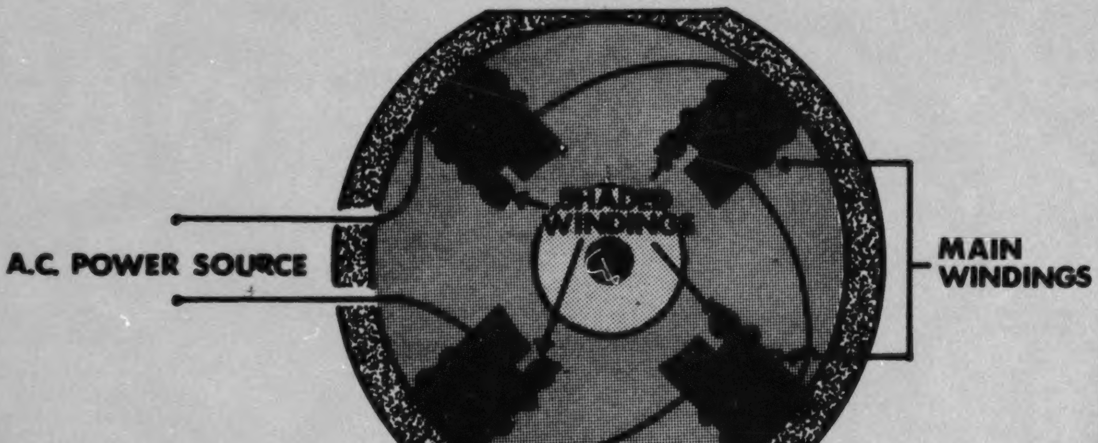
1. SMALL SINGLE-PHASE AC MOTOR
2. LOW STARTING TORQUE—LOW EFFICIENCY
3. 1/100 TO 1/20 HORSEPOWER
4. SIMPLE CONSTRUCTION—FOR LIGHT DUTY SUCH AS SMALL FANS, BLOWERS, ETC.

UNIVERSAL MOTOR


ARMATURE
A.C. OR D.C. POWER
FIELD COILS
CONNECTED
IN SERIES

SERIES CONNECTION OF A UNIVERSAL MOTOR

SHADED-POLE MOTOR

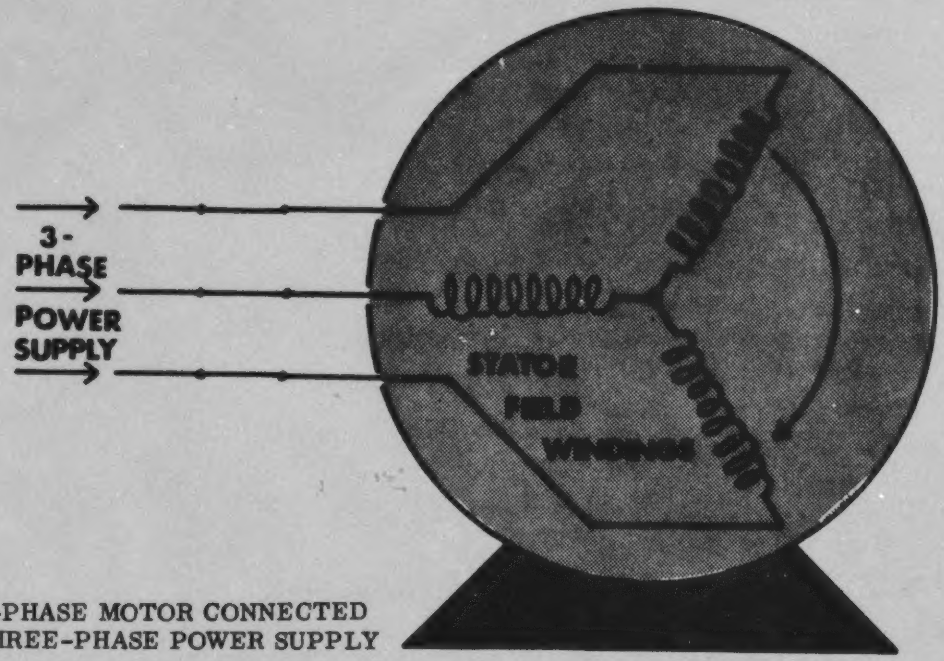

SHADED
WINDINGS
A.C. POWER SOURCE
MAIN
WINDINGS

FOUR - POLE, SHADED - POLE MOTOR SHOWING
MAIN WINDINGS AND SHADED WINDINGS

THREE-PHASE MOTOR

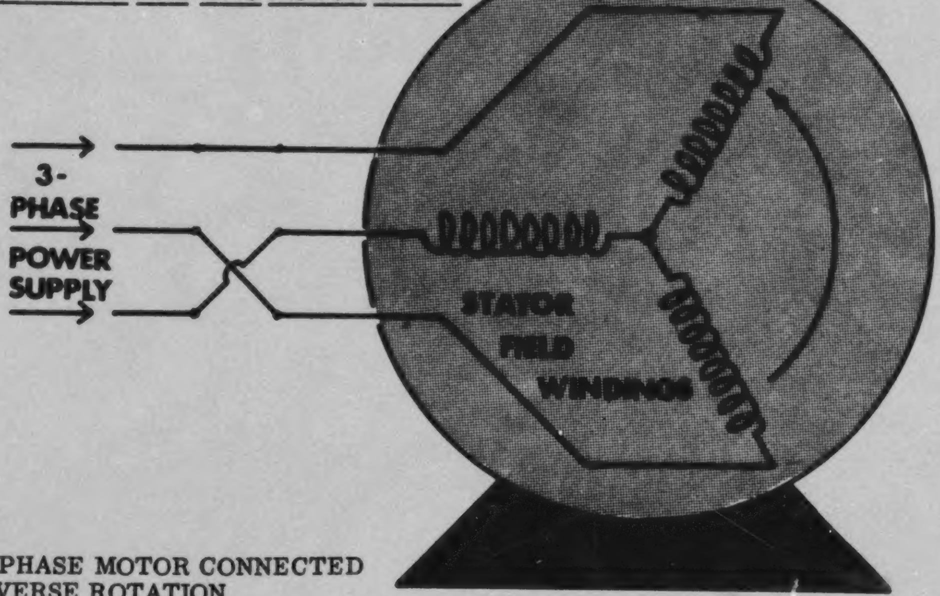
1. SIMPLE CONSTRUCTION
2. USED ON THREE-PHASE ALTERNATING CURRENT POWER SOURCE ONLY
3. MEDIUM TO HIGH STARTING TORQUE
4. LOW, NORMAL AND HIGH STARTING CURRENT
5. "SELF-STARTING"—NO STARTING MECHANISM REQUIRED
6. CONSTANT SPEED MOTOR
7. SIZES—1/3 HP TO SEVERAL THOUSAND HP
8. USED PRIMARILY ON LARGE EQUIPMENT
9. SIZES 1 HP AND LARGER ARE LOWER IN COST THAN SINGLE-PHASE MOTORS

THREE PHASE


3-PHASE POWER SUPPLY
STATOR FIELD WINDINGS

THREE-PHASE MOTOR CONNECTED
TO A THREE-PHASE POWER SUPPLY

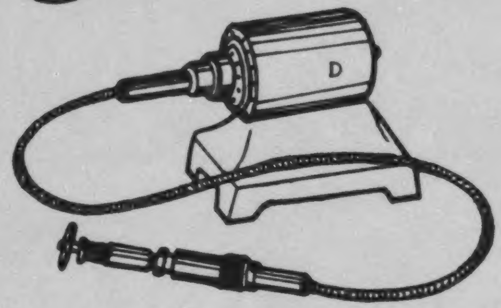
TO REVERSE THE DIRECTION OF ROTATION,
INTERCHANGE ANY TWO MOTOR LEADS


3-PHASE POWER SUPPLY
STATOR FIELD WINDINGS

THREE-PHASE MOTOR CONNECTED
FOR REVERSE ROTATION

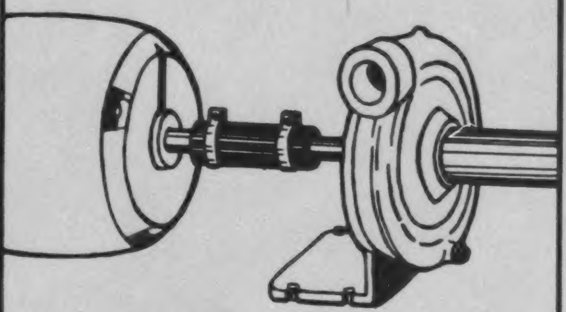
DIRECT DRIVES

①



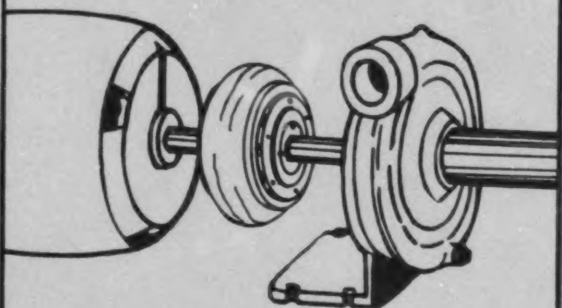
FLEXIBLE SHAFT

②



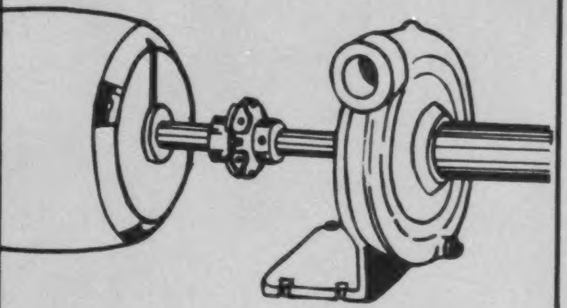
FLEXIBLE HOSE COUPLING

③



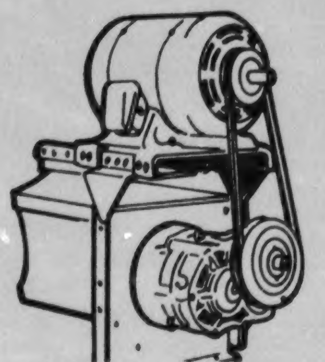
CUSHION-FLANGE COUPLING

④

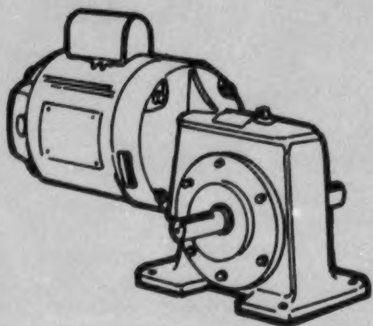


FLANGE COUPLING

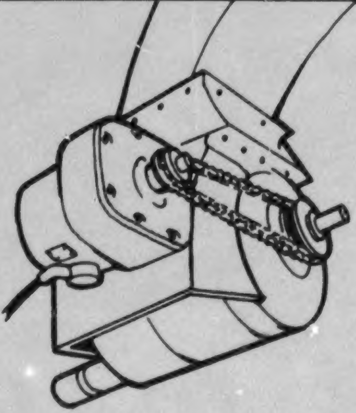
SPEED-CONVERSION DRIVES



PULLEY & BELT

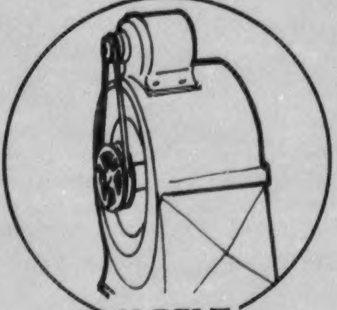


GEAR

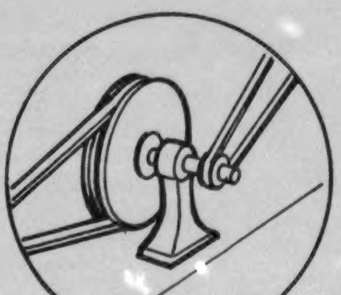


CHAIN & SPROCKET

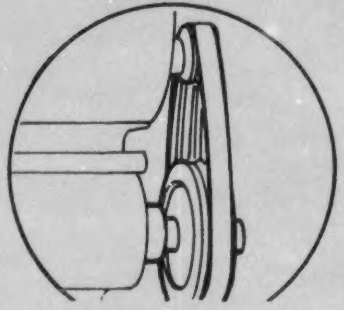
PULLEY & BELT DRIVES



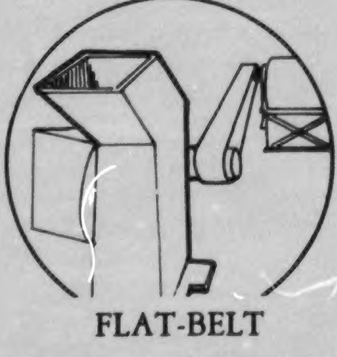
V-BELT



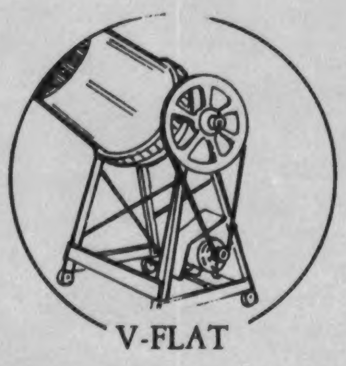
JACK SHAFT



MULTI-V-BELT



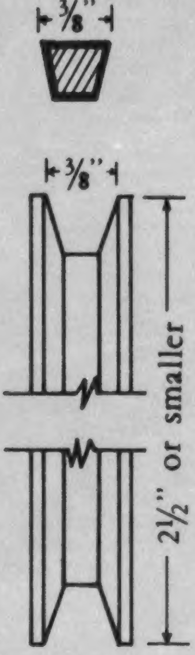
FLAT-BELT



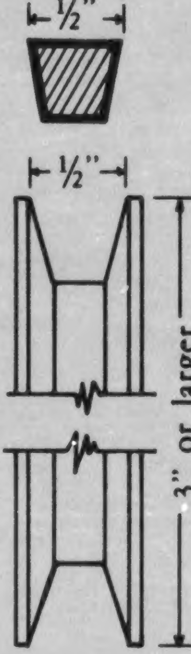
V-FLAT

COMMON V-BELTS & PULLEYS

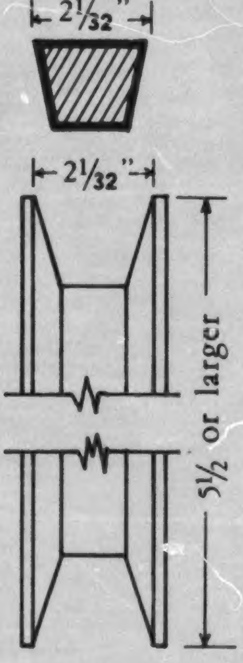
FHP


3/8"
3/8"
2½" or smaller

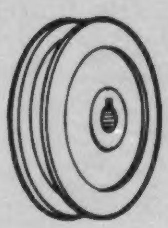
A-SECTION


½"
½"
3" or larger

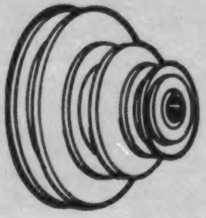
B-SECTION


21/32"
21/32"
5½ or larger

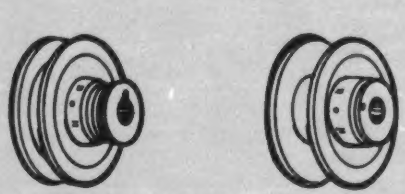
V-PULLEYS



STANDARD



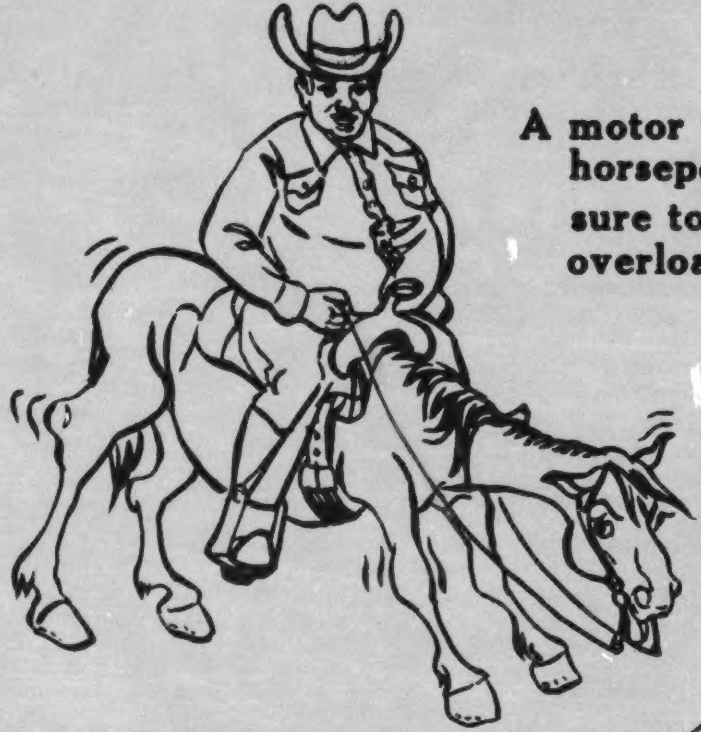
V-STEP



(closed) (open)

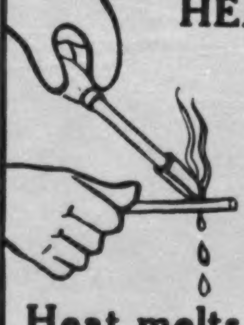
ADJUSTABLE

OVERLOAD

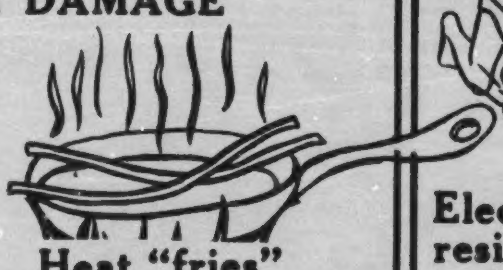


A motor worked beyond its horsepower capacity is sure to breakdown as an overloaded horse will

HEAT DAMAGE

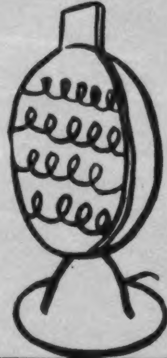


Heat melts



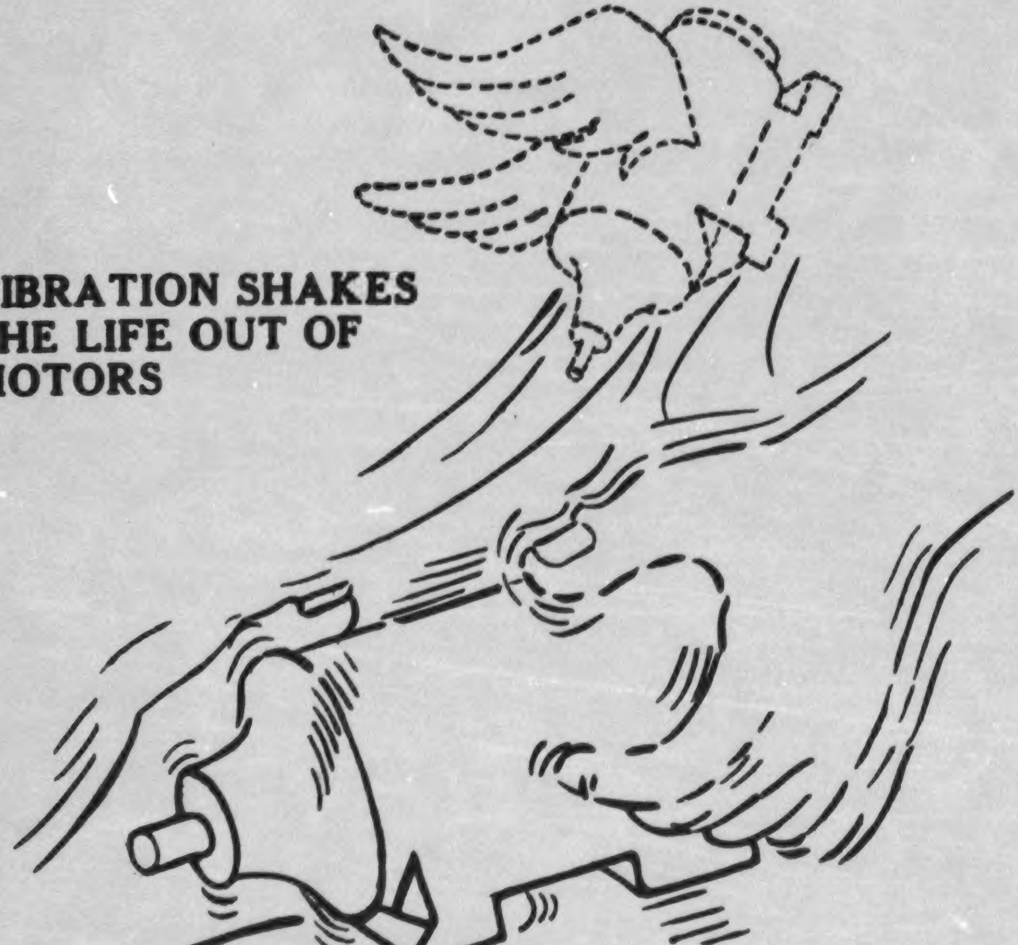
Heat "fries" insulation

Friction makes heat



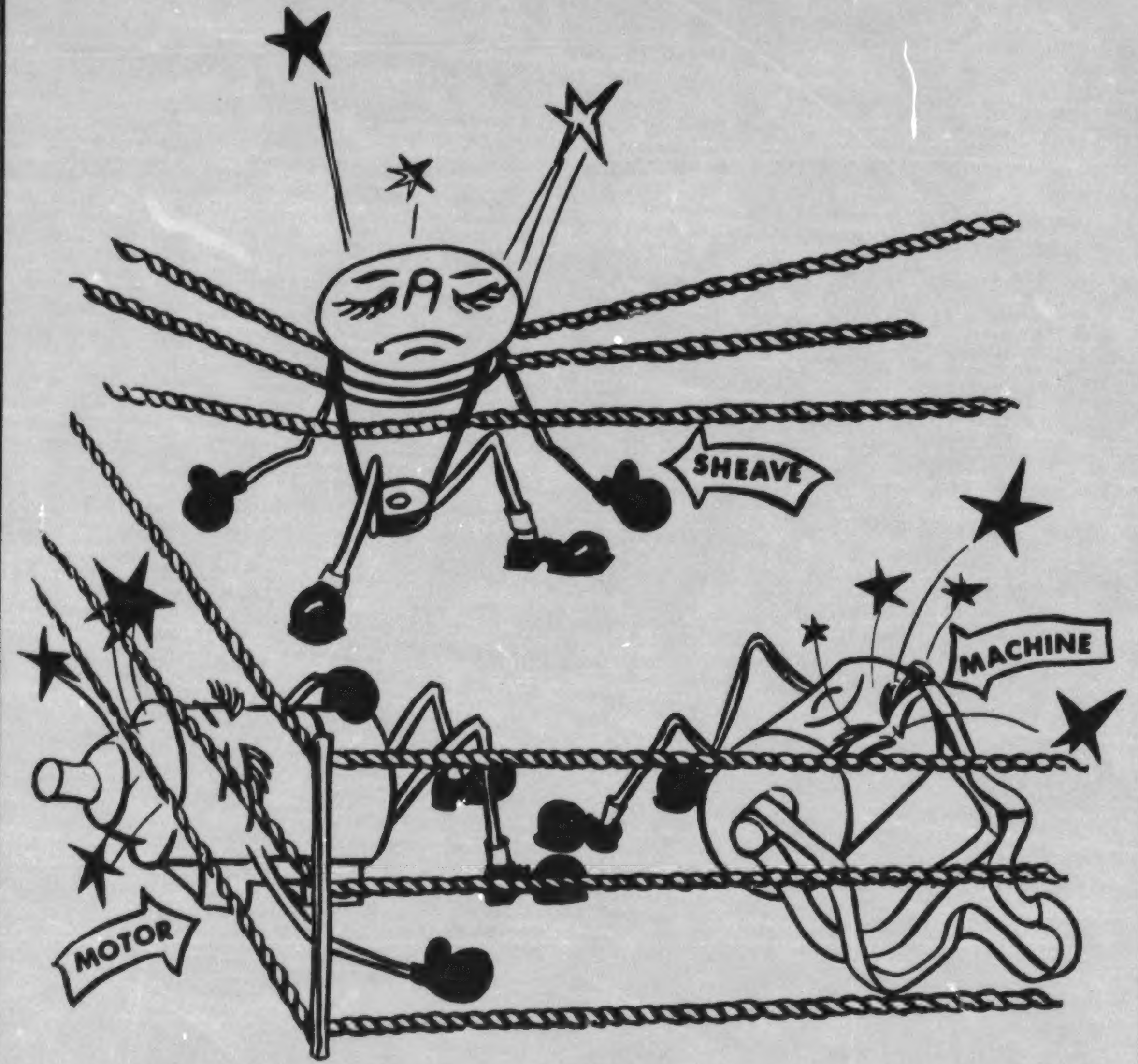
Electrical resistance makes heat

VIBRATION



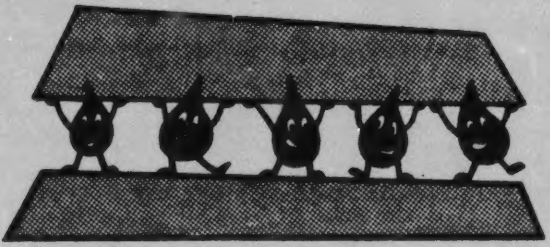
VIBRATION SHAKES THE LIFE OUT OF MOTORS

MISALIGNMENT

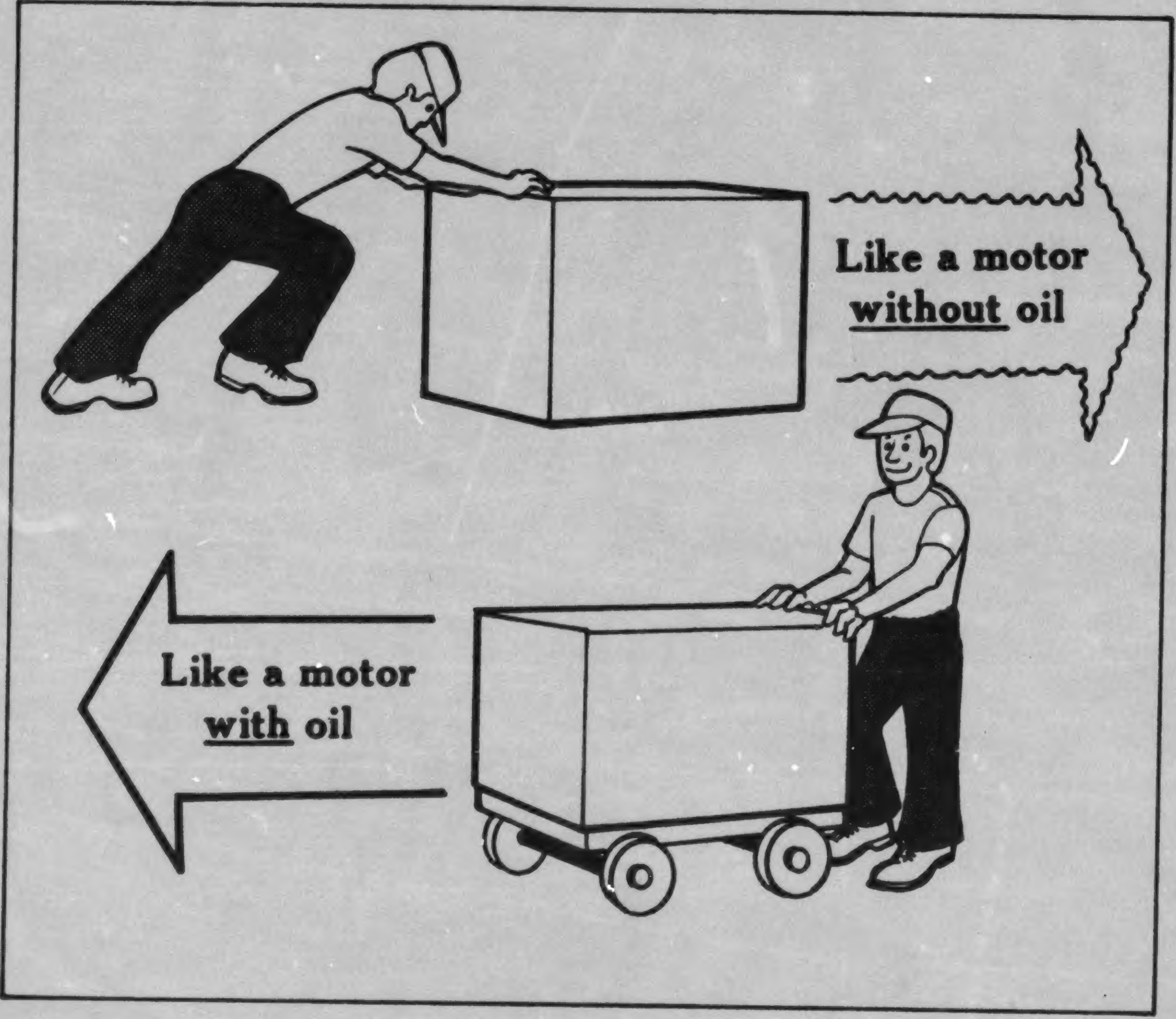

SHEAVE
MACHINE
MOTOR

ONCE MISALIGNMENT STARTS 'EM FIGHTING EACH OTHER . . . THE ONLY QUESTION IS: WHICH WILL GO FIRST?

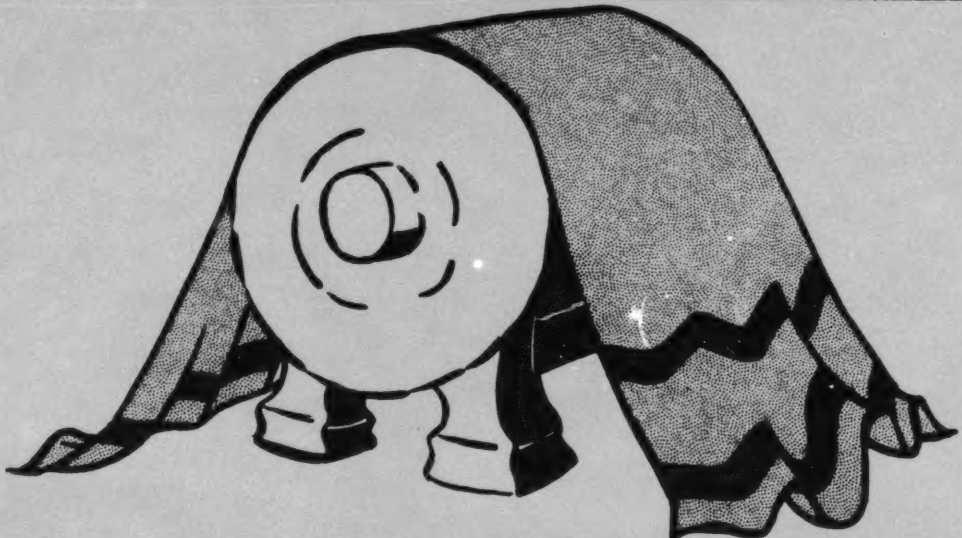
FRICTION



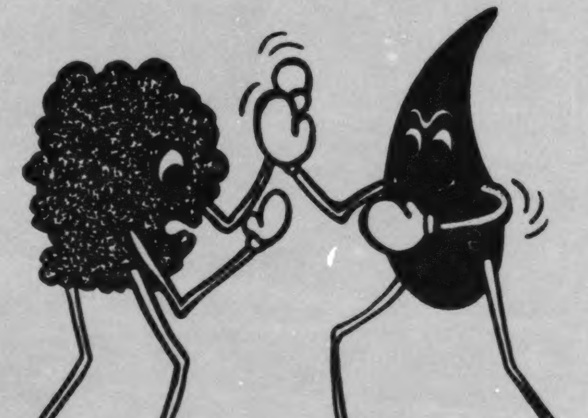
OIL REDUCES FRICTION


Like a motor without oil
Like a motor with oil

DUST



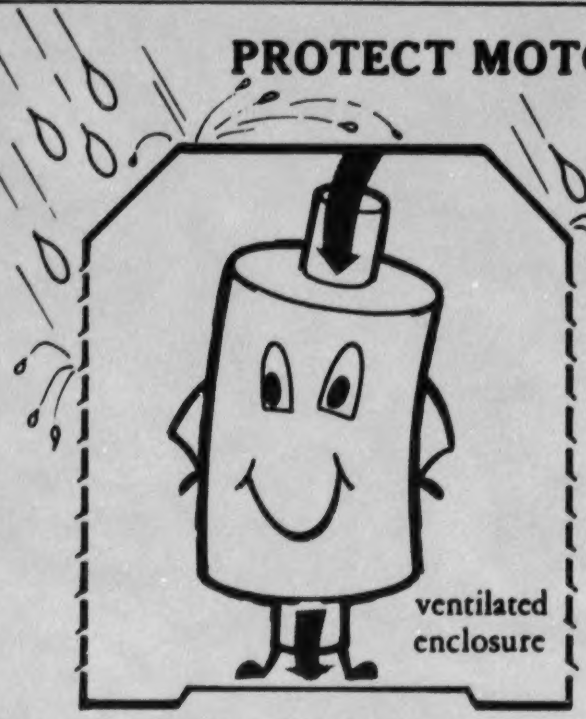
DUST ON ITS WINDINGS "BLANKETS" A MOTOR WITH A LAYER OF INSULATION



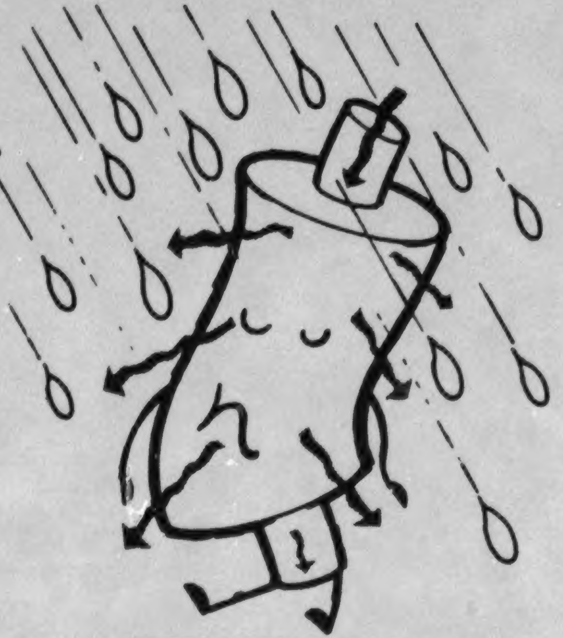
DUST FIGHTS LUBRICATION.

MOISTURE

PROTECT MOTORS FROM MOISTURE

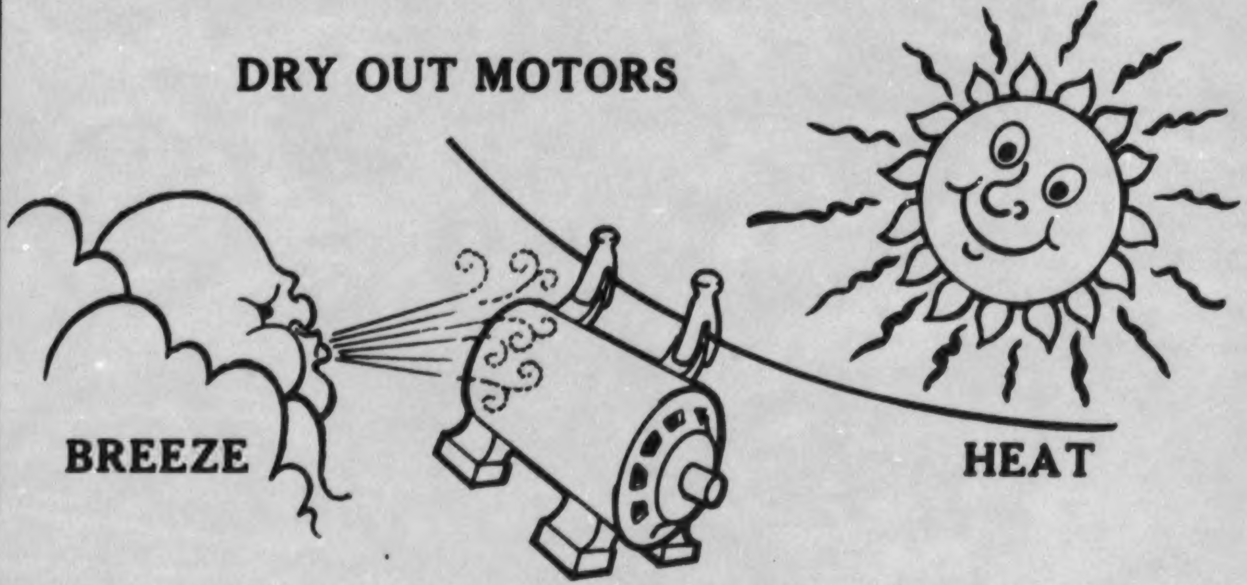

ventilated
enclosure

DRY INSULATION

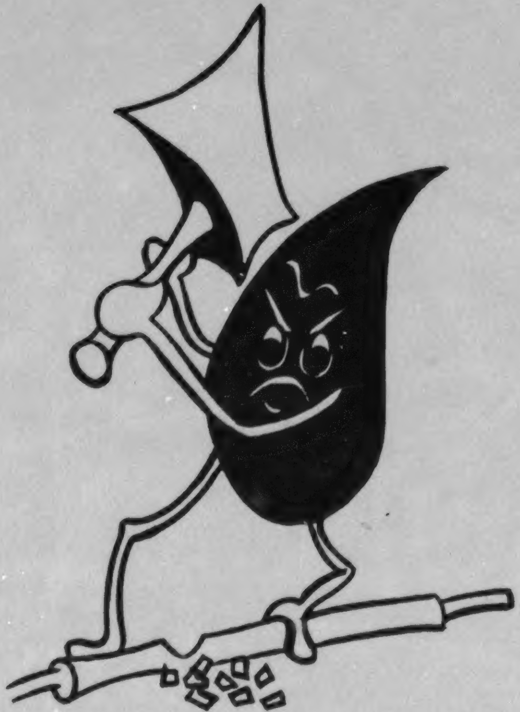


WET INSULATION

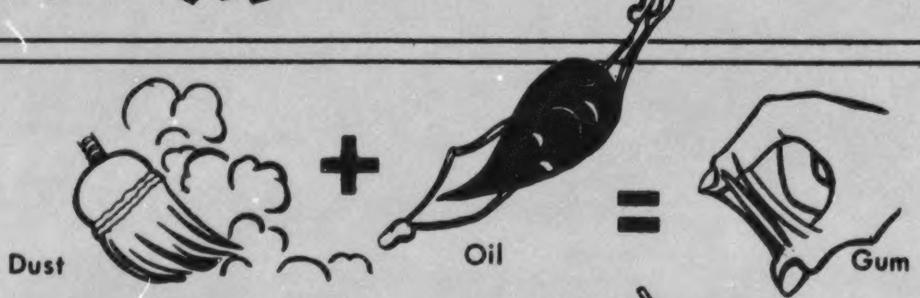
DRY OUT MOTORS

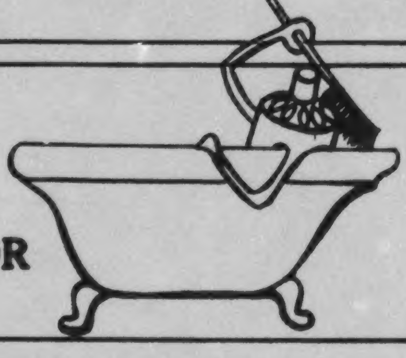

BREEZE
HEAT

STRAY OIL



OIL IS QUICK TO ATTACK INSULATION WHEN IT GETS TO IT!





SOMETIMES A MOTOR NEEDS A BATH...

SPLIT - PHASE MOTOR PARTS

1. Motor Base
2. End Plates
3. Bearings
4. Rotor
5. Fan
6. Shaft
7. Centrifugal Mechanism
8. Starting Switch
9. Oil or Grease Fittings
10. Stator Windings
11. Protective Device

GENERAL AGRICULTURAL MECHANICS

Unit S: Soil and Water Management

Topic 1: Planning Farm Water System

1. Introduction

Water has been described as one of the wonders of nature, and it makes up approximately 80 percent of all living matter. Water must be available at relatively short intervals for the livelihood of all organisms.

The source of about 97 percent of the fresh water used today is ground water, water that seeps downward through the porous beds of soil and rocks. This is the purest form of water because it is purified as it seeps through the soil and rocks and is reasonably safe from contamination. As water seeps through the layers of soil, it fills the porous beds of rocks and sand and forms a reservoir of water called aquafer or water-bearing formation.

Since the water-bearing formations follow the contour of the land and slope downward from hills to the lower areas, the depth of water varies. The upper level at which water is found in the formation is called the water table. Rainfall, amount of snow, seasonal weather variations, and water usage influence the depth of the water table and prevent it from being stable.

Another source of water often used is surface water, water collected on the soil surface. This source has one principal disadvantage. Water is one of the best solvents. Most matter (decayed and vegetable) will dissolve in water, and microscopic organisms breed and reproduce in it. Surface water is easily contaminated.

Springs and cisterns or reservoirs are other sources of water. The possibility of spring water becoming contaminated is always present; therefore, it must be checked periodically for purity. Cisterns are used to store rain water, which can be contaminated as it falls through the clouds. Rain water should be purified by boiling or the addition of chlorine before being used for human consumption.

2. Types of Water Wells

The four kinds of water wells are (1) driven, (2) drilled, (3) dug, and (4) bored.

A metal point with a screened opening just above it is coupled to pipe and driven into the ground to make a driven well. Water flows into the pipe through the screen when the point reaches the water table.

A cable tool (percussion) or rotary drill is used to make a drilled well. These are used in the drilling of deep wells and to obtain a larger flow of water.

Dug wells are excavated holes dug in the ground until the water table is reached. They are lined with rocks, bricks, or concrete pipe to prevent them from caving in.

A bored well is made by digging a hole into the ground with an auger until the water table is reached.

Normally, only a deep well will furnish an adequate supply of water; therefore, most wells with a large flow of water are drilled. As previously stated, the depth of the water table varies; therefore, the well should be drilled deep enough to allow for variations in the water table depth and to provide a margin for drawdown of the water level when pumping.

A steel pipe, called casing, is placed in drilled wells to prevent cave in, serve as a lining for the hole, and seal out surface water and water above the source. The casing should be a minimum of four inches in diameter. This will allow the use of a submersible pump or a two-pipe jet system and ejector pump. In shallow wells or deep wells without an impervious layer, the bottom of the casing should extend several feet below the lowest drawdown of the water, and the casing should extend at least six inches above the well platform.

A floor slab of concrete six inches thick and six feet square is placed around the wellhead to prevent contamination from surface water. A sanitary well cap is used to make a watertight seal between the casing and drop pipe(s), the pipe(s) used to connect the pump to the water supply. Grouting (concrete) is used to seal the space around the outside of the casing to prevent surface and other waters from seeping into the well.

3. Selecting the Well Site

Contaminated water not only affects the health of the family but can spread disease among farm animals. Before water is used, it should be tested for purity by the State Department of Health or a private laboratory.

Transparency No. 1

A knowledge of the soil formation in the area of the site selected is important because some soils, such as coarse gravel and creviced rock, provide very little purification for seeping water.

Surface water seepage, septic tank seepage, and back-seepage are common causes of ground water contamination. Minimum distances have been established for certain contaminants and the water source. These are as follows: pit privy, septic tank, or subsurface pit, 50 feet; seepage pit, subsurface sewage disposal field, and barnyard, 100 feet; cesspool, and livestock, 100 feet. These are minimum distances, and the soil in your area may require greater distances. Surface water can often be prevented from running into the well by the construction of diversions or dams. These should be constructed a minimum of 50 feet from the well.

4. Determining Water Needs for the Farm

A number of factors must be considered in determining the daily water requirements of a farm, and there are several ways that water requirements may be met. On some farms it may be necessary to use more than one source of water. Ground water may be used for the household, while surface water is used for watering livestock. The ground water flow will determine the type of system used (pressure tank or storage reservoir).

Possibly the most important factor to consider in determining the water requirements for a specific farm is the peak demand period. A water system is not adequate if it does not provide all the water needed during the peak demand period, even though it may be more than adequate during the rest of the day. The following discussion will help in determining the peak period demand and the daily water requirements.

A satisfactory water system does not depend as much on the amount of daily water usage as it does on the number of outlets that will be flowing at one time. The figures on water usages given below is based on research and is fairly accurate. The average outlet under 30 pounds of pressure flows at a rate of 200 to 250 gallons per hour (gph). Two outlets flowing at the same time will require from 400 to 500 gph. A farm should have a water system that will allow the use of three outlets at one time (600 to 750 gph).

The "rule of thumb" for estimating water requirements for a household is 50 to 75 gallons per person per day. The higher requirement is used if an automatic water heater, dishwasher, and washing machine are used. If the household has two bathrooms and the above listed conveniences, a 250 gph pump will be required to meet the peak period water demands.

Lawn and garden water requirements should also be considered. Also, if the family has a swimming pool, requirements for it should be estimated. Daily requirements for these items are listed in the following transparency.

Another consideration is fire protection. A small amount of water under adequate pressure is worth several times more water after the fire has burned for a while. The availability of as little as 10 gallons per minute may protect adjacent buildings from burning.

If livestock is to be watered from the farm water system, an estimate for this daily usage should be estimated. The requirements for different classes of livestock are given in the following transparency.

Transparency No. 2

After totaling the daily water requirements, a system should be planned that will meet these requirements. Size of pump, water storage, and layout of pipes are some of the factors to consider.

5. Selecting the Method of Water Storage and Pump

Gravity flow and pressure systems are the two types used. A gravity flow water system normally consists of an overhead storage tank and pipes laid to the different facilities. The water pressure is obtained by storing the water above ground. A pressure system is composed of a pressure tank which serves as a storage for water, or the tank may be connected to a reservoir. A completely automatic water system includes a pressure tank which provides water under pressure. The pressure tank will provide water to several flowing outlets at one time if the tank is large enough and the well provides enough water. It should provide the daily water requirements with two hours of pumping. An overhead tank may require a longer pumping period on a weak well, but the tank should be large enough to hold one day's supply of water.

Selecting a Pump

Some considerations in the selection of a pump are (1) dependability of dealer service, (2) depth of well, (3) size of well, (4) height water is to be lifted, (5) location of pump, and (6) pressure needed to provide an adequate amount of water.

Dealer service is an important aspect to the maintenance of the water system. A reputable dealer should be consulted when planning the system and selecting the pump. The other considerations listed above are discussed below.

The size of pump to select will depend upon the number of outlets flowing at one time. However, the pump should not be larger than the supply available. If a greater flow is required for a part of the day than the well will produce, a larger pressure tank or reservoir must be used.

Pumps lift water by suction, and water is pushed through the pipes by pressure. Suction is brought about by the pump when water is drawn into it. Technically, the pump creates a vacuum in its chamber, and this reduces atmospheric pressure. Atmospheric pressure forces water into the pipe submerged in the water in the well until the pressure in the chamber is equalized. Atmospheric pressure at sea level is 14.7 pounds per square inch. A pound of pressure can raise water in a column 2.3 feet; therefore, the atmospheric pressure will raise water 33 feet in a perfect vacuum (2.3 x 14.7 = 33). Actually, the limit is about 25 feet because of mechanical and hydraulic losses. The figure of 25 feet is reduced by one foot for every 1,000 feet of elevation above sea level. A shallow well pump at sea level can pump water at a depth of 25 feet.

Deep well pumps must be used on wells with water depths greater than 25 feet. A part or all of the pumping mechanism on a deep pump is lowered down into the well to a point where very little if any suction is needed. For example, a submersible pump is lowered into the well and is covered with water.

Transparency No. 3

One type of shallow well pump is the piston pump. The top two illustrations in the above transparency are of a hand operated pump and are shown because piston pumps operate on the same principle. When the handle is pushed down the plunger lifts the water; and it flows out of the spout. While this is taking place a partial vacuum develops below the plunger. This vacuum in the suction pipe causes the water to force open the check valve and water to fill the cylinder. While this is taking place, a valve in the plunger lifts and allows the water to pass to the upper side of the plunger. Water is discharged out of the spout when the handle is pushed down and the plunger is raised.

Double-action piston pumps are shown in the bottom illustrations. When the plunger moves to the right, water is pulled from the well and into the left chamber, and is forced out of the right chamber. The movement of the plunger to the left forces water out of the left chamber and pulls water from the well into the right chamber. The pulling and forcing of water on both sides is the reason it is called a double-action pump. Piston pumps are also referred to as postive action pumps because each plunger stroke moves a constant amount of water.

On deep wells, the cylinder and plunger of piston pumps are placed a few feet above the water or below the water level. The operating principle is the same,however.

Transparency No.4

Another type of pump available is the centrifugal. Both shallow and deep-well centrifugal pumps are available, but they are seldom used for shallow wells. Deep-well centrifugal pumps are often referred to as submersible pumps, and this type has gained in popularity. The pump consists of several impellers driven by a motor which is attached below the pump. The distance the water is lifted and the pressure required at the point of delivery determine the number of impellers needed on the pump. Water pressure is increased as it moves from one impeller to the next impeller. The motor and pump assembly make up a unit. Since the unit is placed below the water level, the pump is always primed because it is always filled with water.

A jet is sometimes added to a centrifugal pump to increase efficiency. The jet consists of a hose, nozzle, and cone-shaped object referred to as a diffuser. In combination these are referred to as ejectors. Water passes through the nozzle at a high speed and reduces the pressure. The combination of increased speed and lowered pressure develops suction around the jet nozzle and provides a pumping action.

The turbine pump has both centrifugal and propelling action and is similar in appearance to a centrifugal pump. The turbine pump has an impeller which spins the water several times as it passes from the pump inlet to the outlet. This gives it more suction than the centrifugal pump.

6. Reading Blueprints and Recognizing Plumbing Symbols

Before installing plumbing (considered to be any part of the water or waste disposal system) on the farm, or in a farm structure or dwelling, the farmer should have a detailed set of plans. The preparation of detailed plans requires a lot of planning and forethought on the part of the farmer, as well as possibly securing the assistance of a professional plumber. In planning an adequate water and waste disposal system, there are several factors that must be considered. Some of these factors are source and availability of power (generally electricity), amount of water or other utilities needed at different locations, distance from source to outlets, pump capacity, storage capacity, the possibility of future expansion (it is expensive to install larger fittings and other plumbing when remodeling), electrical protection, size and kind of pipe and fixtures available, and cost.

There are certain plumbing symbols which make it easier to prepare drawings and blueprints of a plumbing system. In order for a farmer to plan a farm water system and to read blueprints, he must be able to recognize these symbols. Some of the symbols are shown in the following transparencies. If students are not aware of the bell and spigot fitting, the parts are shown in transparency No. 11.

Transparencies Nos. 5, 6a, 6b, 7a & 7b

Blueprints or drawings are necessary to determine the amount of pipe and fixtures needed for a plumbing job. They are also used as installation plans and help to determine costs. Plumbing drawings may be of two kinds, single line or double line. Transparency No. 8 shows examples of each.

Transparency No. 8

7. Selecting Kind and Size of Pipe

The farmer has several choices when selecting the pipe to use for a given plumbing job. The different kinds of pipe, based on the materials used in their construction, are galvanized steel, black steel, copper, brass, cast iron, and plastic. All of the pipe listed above is not necessarily recommended for all plumbing jobs. General information about each kind of pipe is given in the following paragraphs.

Galvanized Pipe - More galvanized pipe is used for plumbing than any other kind. It is very durable and will last thirty to forty years under normal conditions. Galvanized pipe corrodes rather easily in alkaline and acid water and will burst if frozen. It can be purchased in three different weights: standard, extra strong, and double extra strong. The outside diameter of each weight is the same; however, the metal of the extra strong and double extra strong is thicker. The extra strong and double extra strong are usually connected by flanges or welded; therefore, these are not usually used on farm plumbing jobs. Standard galvanized pipe can be purchased in a wide range of sizes. One-eighth inch is the smallest size, while twelve inches is the largest. Pipe size is determined by the diameter of the pipe opening or inside pipe size.

Black Steel Pipe - Black steel pipe may be purchased in the same sizes as the galvanized pipe. Because it corrodes so quickly, black steel pipe is not used on most plumbing jobs. It may be used as gas lines in areas where the pipe is protected from the weather and soil. It is the most economical pipe to buy.

Brass and Copper Pipe - Brass and copper pipes are interchangeable, but more copper is used than brass. There are two kinds of copper tubing, type K, a heavy duty pipe, and type L, the standard copper pipe. Copper tubing is resistant to corrosion and has a life expectancy of forty to 100 years. It can freeze several times before it will burst. Copper tubing is particularly useful in areas where rigid pipes are difficult to lay. It may be purchased in twenty-five foot coils, and there are nine outside dimension sizes from 1/8" to 1".

Plastic Pipe - There has been an increase in the amount of plastic pipe being used on farms. One of the reasons for this increase is the improvement in the quality of the pipe. Plastic pipe is easily laid and does not require any special tools. However, it is easily punctured, loses its strength under prolonged exposure to weather, and should not be used for hot water runs. Most city plumbing ordinances prohibit the use of plastic pipe inside of a home. It is available as rigid plastic pipe in 10 foot lengths and flexible plastic pipe in 60 foot coils. Several grades are available. If the pipe is to be used several years, the most economical plastic pipe to purchase is the best quality. Both fibre and plastic pipes are available in four inch sizes and ten-foot lengths. There is also the perforated type used for septic tank drainage and subsurface field drainage. The solid type is used for house - to sewer, downspout drainage and non-pressure uses. Pipe are joined by driving them into a self sealing coupling.

Cast Iron Pipe - Cast iron pipe is used for drains and vents. The pipe ranges in size from two to twelve inches in diameter. The pipe may be purchased in five foot lengths and in both single and double hubs (explained later). Cast iron pipe does not corrode and will last indefinitely.

After one has reviewed the advantages and disadvantages of the different kinds of pipe and the recommended uses of certain pipe, the following factors should be considered in determining the kind of pipe to use on a given job:

1. Mineral or chemical content of water;
2. Resistance to corrosion;
3. Life expectancy;
4. Recommended pressure;
5. Resistance to deposits;
6. The use of the pipe;
7. Lengths available; and
8. Cost.

Determining the Size of Pipe to Use

The factors to consider in selecting pipe size are as follows:

1. Length of pipe;
2. Number of fittings, valves, and faucets in lines;
3. Kind and condition of pipe used;
4. Rate of flow requirements in gpm;
5. Amount of head (gravity or pressure) available; and
6. Altitude above sea level.

Each of these is discussed below:

Length of Pipe - The length of pipe should be accurately measured from the source of water to the outlet. The length of the pipe is one of the factors that affects the amount of friction in the line. Friction may be compared to a brake and is the degree the flow of water is retarded by the pipe. The friction loss of water flowing at five gpm through 100 feet of one-inch pipe is 1.9 feet, while the same flow through 100 feet of a 3/4-inch pipe is 6.3 feet.

Friction Loss Caused by Valves, Fittings, and Faucets - Couplings, unions, and two or less elbows or T's in a water line can usually be disregarded. However, more than this number can cause a considerable amount of friction loss. An example of friction losses caused by some fittings is given below:

Size	45° Elbow	90° Elbow	T	Open Faucet	Open Check Valve
1/2"	0.78	1.80	3.40	16.00	3.80
3/4"	1.00	2.25	4.50	21.00	5.20
1"	1.35	2.75	5.80	____	6.50

Kind and Condition of Pipe - Scale and corrosion in pipes are responsible for friction loss. Since copper and plastic pipes do not corrode, the friction loss due to scale in these pipes is not considered. The smoother the insides of galvanized pipe, the less the loss from friction. Water will flow faster in new galvanized pipes than it will in pipes used for several years. To compensate for several years of use, most friction tables are based on pipes in use from 10 to 17 years. The following table is based on pipe used for 15 years.

Friction Resistance to Different Rates of Water Flow

Rate of Flow (gpm)	Diameter of Pipe in Inches				
	1/2	3/4	1	1 1/4	1 1/2
	(Loss in Feet of Head per 100 Feet)				
3	15.80	4.10	1.26	____	____
5	41.00	10.50	3.25	0.84	0.39
6	54.86	14.15	4.39	1.15	0.52
8	____	24.05	7.50	1.93	0.89
10	____	38.00	11.70	3.05	1.43

The value of 0.7 should be multipliedtimes the above to get the friction loss for new pipe.

Attention is directed to the difference in friction loss at the rate of three gpm for 1/2- and 3/4-inch pipe. The loss from 3/4-inch pipe is about one-third the loss from 1/2-inch pipe.

Although the inside diameter of copper tubing is smaller than galvanized pipe and there is less friction loss from plastic pipe, it is recommended that the same friction table be used for all three kinds of pipe.

Discharge Rate or Rate of Flow - The discharge rate from a faucet is three to five gpm. The total discharge rate for all faucets on a line should be considered and is necessary to determine the total rate of flow.

Available Head or Pressure - This is important because the more head (the more force on the line), the more the line can lose from friction loss; and a smaller pipe can be used.

Altitude Above Sea Level - This has previously been discussed and affects the suction life of pumps.

Only five pipe sizes and five rates of flow are shown in the friction table above. Similar tables are available on larger pipes and greater rates of flow. The following example is given to assist one in using the table. The friction loss for a 3/4-inch pipe 200 feet long and flowing at the rate of five gpm is determined.

1. Referring to the above table, one will notice that there is a loss of 10.50 for each 100 feet.
2. Since the pipe length is 200 feet, 10.5 must be multiplied by 2 (2 x 10.5 = 21.0 feet loss).

Other head losses can be determined in the same manner.

An example using a storage tank and gravity flow is as follows:

Assume the storage tank is 40 feet above the faucet and the faucet is 200 feet from the tank. The rate of flow desired is four gpm. The head loss from fittings, valves, and faucets should be included, but they are omitted from the example. If they were included, their equivalent in feet would have to be totaled and added to the length of the pipe.

1. The gravity head available is 40 feet. The friction loss for the 200 feet of pipe cannot exceed this.
2. Using the above table, a four gpm rate of flow for 1/2-inch pipe is 27.00. 27.00 x 2 = 54.0 feet. This exceeds the 40 feet of head; therefore, a 3/4 inch pipe (7.00 x 2 = 14 feet) must be used.

8. Pipe Fittings

A part of any plumbing skill will be in developing the ability to recognize the different kinds of pipe fittings. Fittings can be purchased in the same sizes as pipe. Some fittings that may be used with different kinds of pipe are shown in the following transparencies.

Transparencies Nos. 9, 10, and 11

The plastic fittings shown in Transparency No. 11 are used with a clamp. There are also plastic fittings that may be glued to the pipe.

Fittings make pipe much easier to install and are used in the following ways:

1. To connect pipe;
2. To change the direction of pipe;
3. To reduce the size of pipe; and
4. To plug pipes.

Fittings have the same inside dimension as the pipe they are used on and are designated by the size of pipe they fit. For example, one inch tees fit one inch pipe.

Transparencies Nos. 12a and 12b

There are several kinds of valves used in plumbing. The most common are the safety, check, hydrant, stop and waste, gate, and globe. Safety valves are used on hot water heaters to release water and temperature. When the pressure on the spring is exceeded by the pressure under the seat, the seat is lifted, and water and air flow through.

Check valves are used to prevent a backflow of water. They are automatic and open and close with the direction of flow.

Globe valves are used to cut off the flow of water or to drain the water line. They should be installed with the pressure under the valve seat. Otherwise, they will leak. The gate valve is used the same way as a globe valve. It has an advantage over the globe valve; in that , it will not restrict the flow of water.

There are two types of stop and waste valves, globe and ground key. They are used to shut off the pressure and drain the line.

A hydrant valve is similar to a stop and waste valve. When the water is turned off, the pipe is drained from the surface back to the valve. This prevents freezing in cold weather.

9. Plumbing Tools

In order to install pipe and plumbing, certain tools are needed. The following transparency shows most of the tools needed to install plumbing.

Transparencies Nos. 13a, 13b & 13c

Pipe Vise - The farmer may use a combination pipe and machinist's vise or a regular pipe vise. Three different kinds are shown in the transparency.

Pipe Cutter - A small amount of pipe may be cut with a hack saw; however, pipe cutters require less effort and generally make a straighter and smoother cut. Galvanized pipe cutters and tube cutters are available.

Stocks and Dies - Several brands are available, and there is some variation in quality among the different brands.

Pipe Wrenches - Several kinds and sizes of wrenches are available. Usually two wrenches are needed to tighten and loosen pipes. The farmer should select wrenches that are large enough for the job.

Burring Reamer - A burr is made on the end of a pipe while it is being cut. A reamer should be used to remove the burr. Two types of reamers are shown in the transparency. One is used on galvanized pipe, while the other is for copper tubing. The copper tubing reamer is a part of the tube cutter.

Flare Tool - The Flare tool is used to form a flare on the ends of copper tubing when flare type fittings are used.

10. Measuring, Marking, Cutting, and Reaming Pipe

To accurately measure the length of a pipe, one must know the distance that the pipe screws into the fitting and the distance taken up by the fitting. Different size pipe and fittings require different distances. Charts are available that give the distances taken up by fittings and the distance pipe is screwed into fittings. Another method would be to measure the distance taken up by the fittings. After using various fittings on plumbing jobs several times, one will learn the distances taken up by each size fitting.

Transparency No. 14

Measuring Pipe - Three methods of measuring pipe are given below; however, there are other methods.

One method is called end to end measurement. This is the measurement of the pipe without any fittings. The distance between the fittings is measured, and an allowance is made for the thread that screws into the fitting. One-half inch should be allowed for the fitting if one inch pipe is used, and three-fourths of an inch of thread is allowed for pipe 1 1/4 inches to two inches in diameter. This method should not be used when accurate measurements are needed.

A more accurate method for measuring pipe is to measure the distance from the center of one pipe to the center of the other pipe (as shown in Transparency 14, Figure B), and subtract the diameter of the pipe for each thread. This is called center to center measurement. A farmer using one inch pipe, for example, would subtract two inches from the length of the pipe, one inch for each end of the pipe.

The end to center measurement is the third method. An elbow is first tightened on the threaded end of a pipe, and the measurement is taken between the center of the elbow and opposite end of the pipe.

Most pipe drawings are shown as center to center measurements.

Marking Pipe - The length of the pipe may be measured with a ruler or tape measure, and the pipe should be marked with the edge of a three-cornered file.

Cutting Pipe - To prepare pipe for cutting, the farmer should fasten the pipe in a pipe vise with the mark made by the file approximately four inches in front of the vise. The procedure for cutting the pipe is as follows:

1. The opened pipe cutter is slipped over the pipe, and the cutter handle is turned until the wheels are snug against the pipe at the mark.
2. A few drops of oil (cutting oil) are placed on the mark.
3. The pipe cutter is turned around the pipe, and the screw handle is turned one-fourth turn each revolution of the cutter until the pipe is cut off.
4. The reamer is used to remove the burr that is left on the inside of the pipe after it is cut. If the burr is left in the pipe, it will restrict the flow of water.

11. Threading Galvanized and Black Pipe

A pipe thread is tapered so that it will make a tight joint when the fitting is screwed on to the pipe. In order for the joint to be tight, the thread must be cut properly. The procedure for cutting a pipe thread is as follows:

1. The pipe is cleaned of dirt, rust, and other materials.
2. The rough edges are removed from the end of the pipe to be threaded.
3. The pipe is secured in a vise.
4. Cutting oil or lard oil is applied to the die.
5. Inward pressure is applied to the die as it is turned on the pipe. After the die becomes engaged on the pipe, the inward pressure should be discontinued.
6. The pipe should be oiled frequently ahead of the die.
7. The threading is continued until one thread is showing outside of the die. More threads should be showing on large pipe. The die should never be turned backwards or back and forth. This will ruin the threads.
8. The die is backed off of the threads carefully. If the die should catch, it should be turned forward again to dislodge the metal chips.
9. The pipe is cleaned of oil and removed from the vise. The die also should be cleaned.

12. Flaring Copper Tubing

When flare type fittings are used, it is necessary to make a flare at the ends of the tubing. The procedure for flaring the tubing is as follows:

1. A sleeve nut is slipped on the section of copper tubing.
2. The burr, if present, should be removed from the end of the tubing.
3. The tubing is wrapped with cloth or leather (to prevent marring) and placed in a vise.
4. A few drops of oil are applied to the flaring tool.
5. The flaring tool is placed over the end of the tubing, and the tubing is placed flush with the surface of the tool.
6. The flaring tool is screwed into the end of the tubing to make a flare.
7. The flare tool is removed, and the sleeve nut is placed in position. The flared end is now ready to be placed on the fitting.

13. Assembling Tubing with Solder Fittings

A gas soldering or brazing torch is recommended for soldering fittings. Also, a flux, recommended for use with the solder, should be used. The following is a step by step procedure for assembling copper pipe with solder fittings:

1. The copper tubing is cut square, and the burr is removed.
2. The outside area of the tubing that will be covered with the fitting is cleaned thoroughly.
3. The inside of the fitting is cleaned thoroughly.
4. Flux is applied to the cleaned portion of the tube.
5. The fitting is placed on the tubing, pushed against the shoulder of the fitting, and is turned several times to distribute the flux.

6. Heat is applied until the flux boils and the copper will melt solder.
7. Solder is applied until it appears completely around the edge of the fitting. Because of the close fit of the fitting and the pipe, the solder will flow by capillary action throughout the joint when the joint is properly heated. This action is in every direction - up, down, or sideways. The flame should be removed from the joint as quick as the joint is filled with solder. Excessive heat will cause the solder to boil out of the joint.
8. The joint is allowed to cool.

14. Measuring, Cutting, and Assembling Cast Iron Pipe

This type of pipe is often referred to as cast iron soil pipe because it is used for drains and vents and is in contact with the soil.

When measuring cast iron pipe, an allowance should be made for the hub. Different size pipe require a different allowance. After the pipe has been measured, a mark, which will indicate the area to cut, should be made with chalk around the pipe.

When ordering cast iron pipe, the farmer should order enough double hub pipe to make all of the cuts from. Cast iron pipe may be cut by three methods: a cast iron pipe cutter, a hacksaw, or a chisel. An explanation of cutting cast iron pipe with a hacksaw and chisel is given in the following paragraphs.

Transparency No. 15

If a hacksaw is used, a 1/16 inch deep cut is made around the pipe. After the cut is make, the pipe is tapped with a hammer until it breaks. The hacksaw should be used only on service weight pipe. A cutter or a cold chisel should be used on heavier pipe.

When a cold chisel is used to cut the extra heavy weight pipe, the farmer should place the pipe on a board as shown in the transparency. A file is used to mark the pipe, and a chisel is used to make a light cut around the pipe. The pipe is rolled on the board as it is cut.

There are two kinds of joints that are used in connecting cast iron pipe. These are vertical and horizontal. The procedure to follow in making a vertical joint is as follows:

1. The hub is placed in an upright position.
2. The pipe and joint are cleaned, and the spigot end is placed into the hub its full depth.
3. Oakum, a form of rope, is wrapped around the pipe and packed with the yarning iron. The joint is filled within 3/4 inch from the top of the hub. The oakum must be packed tightly and evenly to make a water proof joint.

4. Molten lead is poured into and around the joint. Enough lead should be picked up in the ladle to fill the joint in one pouring.
5. The lead is allowed to cool, and the joint is calked (packed) to make it watertight. A hammer and calking iron are used for this.

The procedure for assembling a horizontal joint is the same, except an asbestos joint runner is used to pour the lead in the hub.

15. Sewage Disposal System

Plans for the sewage disposal system should be developed at the same time as the water system because an adequate sewage disposal system is necessary to safeguard health and prevent disease.

Sewage passes through three stages before it becomes harmless: (1) sedimentation, (2) decomposition, and (3) purification. The solids are separated by the liquids in the sedimentation stage, while two types of bacterial action (aerobic and anaerobic decomposition) cause their decomposition. These bacteria will usually establish themselves in a septic tank; however, they may be purchased commercially and placed in the septic tank. The purification of sewage is accomplished as the liquid is aerated through the soil in the disposal field.

The most inexpensive method of sewage disposal for the farm home is a septic tank with an underground disposal system. However, in some areas it may not be possible to use this system. Heavy, impervious soil or a high water table will prevent the use of a septic tank. Before installing this type of sewage disposal, one should run a percolation test to determine if a septic tank and underground disposal system will function properly.

Transparency No. 16

The three parts of a sewage system are the sewer line from the house to the septic tank, septic tank, and final disposal system. A distribution box may or may not be used as a part of the disposal system.

Sewer Line from the House to the Septic Tank - The length of the sewer line to the septic tank will be determined by the slope of the ground, location of house and well, and the disposal field. All sewer lines should be located to prevent contamination of the well by sewage.

The drain line should be laid in a straight line and at an uniform grade. The grade of the drain is determined by the size of the line, but not less than two feet per 100 feet of line is recommended for four inch drain pipe. Less drop may be used on larger pipe. The pipe should be laid on firm soil.

Septic Tank - The septic tank can be purchased, or it may be constructed on the site. The size of the septic tank should be determined by the number of people in the family plus others that may be expected to use the system. It should be large enough to hold the sewage for three days. A daily allowance of forty to fifty gallons per person is usually made. The septic tank should be located down hill from the home and no closer than thirty feet.

The contents of a septic tank are composed of scum, liquid, and sludge. Grease and lighter solids rise to the top to form scum, and the heavier solids sink to the bottom. Liquid remains in between. The outlet on the septic tank is constructed so as to prevent solids from leaving the tank.

Final Disposal System - Since only liquid passes through the outlet line, it is not easily clogged; nevertheless, a grade of two feet for 100 feet should be used. This will increase its capacity and decrease the possibility of freezing.

The size of the disposal area is very important and is determined by the capacity of the soil to absorb liquid, size of the disposal system, amount of liquid to be disposed, and size of trench where pipes are laid. There are several ways of running disposal lines, and they may be of cast iron, vitrified clay cement, or fiber tile. Some systems have the disposal lines running from a distribution box, while others have the lines running directly from the septic tank. Regardless of the layout of the disposal tile, one should have at least two runs of tile equal in length. The runs should not exceed 100 feet in distance.

The grease trap, which is connected to the kitchen sink and is another part of the waste disposal system, may be connected to the septic tank, or it may bypass the septic tank and go directly to the disposal lines. Since grease is lighter than water, it collects at the top of the trap. Water drains off from the bottom of the tank. Grease must be removed before it fills the trap; otherwise, the grease will drain into the sewer, which eliminates the value of the trap.

16. Maintaining the Farm Water Supply

In order to avoid delays, save money, and maintain a constant supply of water to farm buildings and for livestock, the farmer should be able to make minor repairs to his water system. If a farmer has an extensive water system or several systems on his farm, it may be wise for him to obtain the necessary tools and to perform the major repairs.

Repairing Faucets and Valves - Repairs to faucets and valves are possibly the maintenance jobs most often performed by the farmer. Faucets are used at water discharge points, while valves are used to close off a part of the plumbing system. Faucets and valves are very similar, and the instructions for repairing them are the same. There are several kinds of each, but all are repaired in about the same manner.

Transparency No. 17

Mixing faucets, found on sinks, bathtubs, and showers are actually two separate units. Each unit should be repaired independently. If a faucet drips when closed, or vibrates ("sings" or "flutters") when open, it usually has a worn washer. If it leaks around the spindle when open, new packing is needed around the stem.

The following procedure may be used to replace the washer:
1. The water is shut off at the valve nearest to the faucet.
2. The faucet is disassembled in the following order:
   a. Handle
   b. Packing nut
   c. Packing
   d. Spindle
3. The screw and worn washer are removed from the spindle. A new washer is installed in the cup.
4. The seat should be examined. If it is rough, it should be refaced with a seat-dressing tool, which may be purchased from a hardware store.
5. The faucet is reassembled. To replace the packing, one should remove the handle, packing nut, add packing, and install a new packing washer. If a packing washer is not available, stranded graphite-asbestos wicking may be wrapped around the spindle. The packing nut is screwed tight against the wicking.

Repairing Leaks in Pipes - Leaky pipes are usually caused by corrosion or damage from freezing, machinery, or animals. Generally when corrosion exists, it is in varying degrees for the entire length of the pipe; however, an exception to this occurs where different kinds of metal are joined, such as copper and steel. There is a tendency for different kinds of metal to corrode much faster where they are joined. It is possible at times to prevent corrosion by testing the water and taking the proper precautionary measures if they are needed. The method used to repair a leaky pipe is determined by the area in which the pipe leaks and the size of the leak. Leaks may be repaired as follows:

1. Small pipe leaks - Emergency repairs can be made with a rubber patch, metal clamp, or sleeve. However, the pipe should be replaced as soon as practicable.
2. A leak at a threaded connection - This type of leak can often be stopped by unscrewing the fitting and applying a pipe joint compound. The compound, available from most plumbing supply firms, seals the joint when the fitting is screwed back together.
3. Large leaks in a pipe - There are several ways of repairing this type of leak. The old pipe can be removed and plastic pipe put in its place.

(Clamps are used to hold the pipe in place.) This type of repair should not be used in the farm household. If the leak is near a joint, the damaged pipe may be cut out and a new pipe installed with the use of a union.

4. Leaks at solder joints - Due to vibration or some other reason, solder joints sometimes start leaking. These may be resoldered if they are accessible.

Repairing Leaks in Storage Tanks - Most farms have several tanks for storing water or other liquids. The life of these tanks may be prolonged by repairing the leaks. One method of repairing a leak in a tank is to use a rubber washer, brass washer, and toggle bolt. It may be necessary to drill the hole larger in the tank to insert the toggle bolt. The rubber washer, brass washer, and nut are placed on the toggle bolt in the order given. The toggle bolt is pushed through the hole, and the nut is tightened until the rubber washer is compressed against the tank. This repair will postpone buying a new one, but the tank will eventually have to be replaced.

17. Repairing Water Closets

There is some variation in the design of flush toilets, but they are enough alike that one should be able to repair them by following these instructions.

Transparency No. 18

The flush valve, intake (float) valve, and float ball are generally the parts on a water closet that need repairing. Instructions for repairing each are given.

Repairing the Flush Valve - A leaky flush valve is usually caused by the decomposition of the rubber ball. It gets soft and fails to seat properly. Other parts that may cause the flush valve to leak are the trip lever, connecting rod, or lift wire. If they cannot be repaired, they should be replaced.

To replace the rubber ball, stop the flow of water by tieing the float or propping it up with a piece of wood. The lift wire is screwed out of the old rubber ball and screwed into the new one. This can be accomplished without removing the tank ball guide from the overflow pipe.

Repairing the Intake Valve - A worn plunger washer in the supply valve will cause this valve to leak. If the washer is not causing the leak, the float-valve assembly should be replaced. The procedure for replacing the washer is as follows:

1. The water is shut off, and the tank is drained.
2. The two thumbscrews that hold the levers are unscrewed, and the levers are pushed out.
3. The plunger is lifted out, and the cup on the bottom is unscrewed. A new washer is inserted.
4. The washer seat should be refaced if needed.

If the float ball is leaking or fails to rise to the proper position (correct water level is about one inch below the top of the overflow tube), the ball should be repaired or replaced.

Water Closet Bowl Removal - If the water closet bowl leaks, it may be necessary to remove it to repair the leak. The procedure is as follows:

1. The water is shut off.
2. The tank and bowl are emptied.
3. The water pipes are disconnected from the tank.
4. If it is a two-piece unit, the water bowl is disconnected from the tank.
5. The seat and cover are removed.
6. The bolt covers are removed, and the bolt holding the bowl to the floor flange is removed.
7. The bowl is repaired.
8. The tank is installed, and the water pipes are connected.
9. The bowl is checked for leaks by flushing a few times.
10. The seat and cover are installed.

18. Clearing Clogged Drains and Traps

Drains become clogged by objects falling into them, or by an accumulation of dirt and other matter. They should be cleaned periodically rather than waiting until they are clogged. Periodical cleanings are much easier.

If a fixture trap is clogged, usually the trap must be removed and cleaned to unstop the drain. If a drain pipe is clogged, there are several methods that may be used to unclog the drain:

1. A plunger, often called a plumber's friend, can be used successfully sometimes to unclog drains.
2. Cleanout Augers - Flexible cables are often used to clear obstructions in drain pipes. Some plumbers have power driven augers, and it may be necessary to secure their services if the drain is closed by root growth. If it becomes necessary to use a root saw, the drain should be eventually relaid.

   Water pressure from a hose may break up an obstruction or force an object through the pipe. If this method is used, the hose should be inserted well into the pipe, and rags should be wrapped around the hose where it enters the pipe to minimize a backward flow of water.

   Chemical cleaners are an effective means of loosening grease and soap from pipes; however, they should not be used in pipes that are completely stopped up. They must be brought in direct contact with the stoppage to be effective. After chemicals are used, the pipe should be flushed with cold water.

19. Maintaining Water Pumps

The two most common water systems, pressure and gravity flow, are discussed.

Gravity Flow System - If the gravity system is used, a pump and storage facility must be maintained to provide an adequate water supply. The maintenance problems usually connected with a gravity flow system are the repairing of leaks and the maintaining of an adequate flow of water. Observing the daily water consumption on the farm will assist the farmer in detecting leaks. If an abnormally large amount of water is used during a short period, or if there has been a considerable increase in water consumption without an apparent reason for the increase, there is a possibility that the system is leaking. Underground leaks are difficult to detect. If after walking along the routes of the underground pipes, the farmer has not detected a leak, indicated by a wet or damp spot, he should turn off a part of his water system to determine the area of greatest consumption. If the area of the leak canbe determined, all connections should be checked for leaks. If the leak is still undetected, it may be necessary to dig up some of the pipe.

Since the maintenance problems of wells and pumps are similar, regardless of the kind of water system, pump and well maintenance is discussed under the pressure system.

Pressure System - Troubles with a pressure system are more difficult to determine because of the automatic controls and safety devices.

The following list of possible problems shows what one might encounter in maintaining a well and pressure system and the areas that should be checked to eliminate the problem:

The Pump Fails to Deliver Water:

1. Air leak in suction pipe
2. Water level below the end of the suction pipe
3. Pump lost prime
4. Stuck foot valve
5. Plugged suction
6. Dry well
7. Plugged jet
8. Cracked cylinder
9. Worn leathers (reciprocating pump)
10. Worn valve on jet pump
11. Broken plunger rod

Pump Fails to Deliver a Normal Amount of Water:

1. Pipe valve leaking
2. Cracked cylinder
3. Air in suction pipe

4. Belt to motor is too loose
5. Low voltage
6. Suction pipe too small
7. Improper setting on pressure regulator

Pump Stops and Starts Often:

1. Not enough air in pressure tank
2. Leaky foot valve
3. Leak in plumbing
4. Tank too small
5. Air pump out of order

Air Spurts from Faucets:

1. Too much air in tank

Pump Motor Fails to Run:

1. Power off
2. Broken power line
3. Blown fuse
4. Circuit breaker open
5. Burned motor
6. Reset fuse blown
7. Malfunctioning motor switch

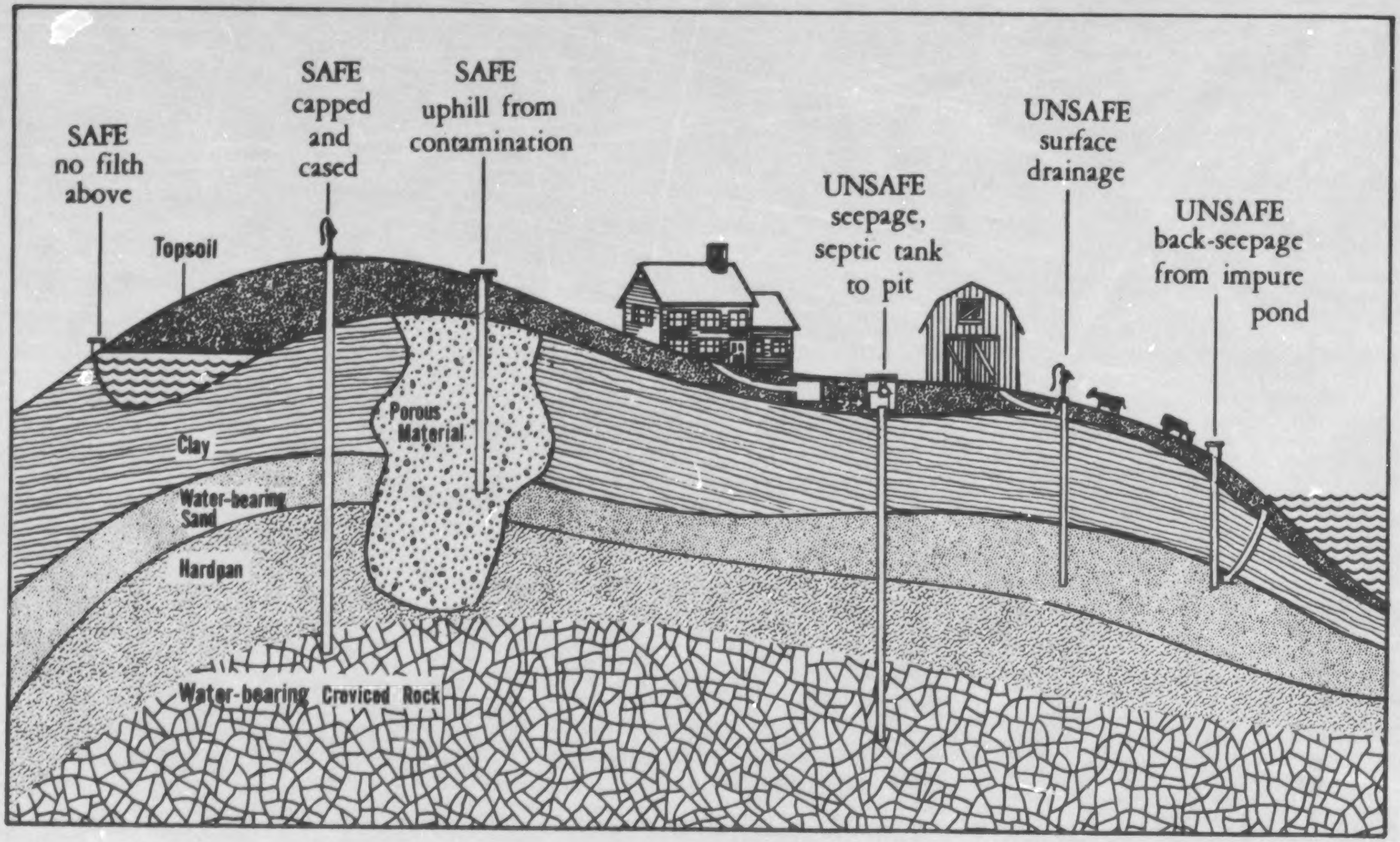
References:

1. Wright, Forrest B., Rural Water Supply and Sanitation, John Wiley and Sons, Inc., New York, New York, 1956

2. Phipps, Lloyd J., Mechanics in Agriculture, The Interstate Printers and Publishers, Inc., Danville, Illinois, 1967

3. "Planning for an Individual Water System", American Association for Vocational Instructional Materials, Egineering Center, Athens, Georgia, 1972

SELECTING A SITE FOR A WATER SOURCE

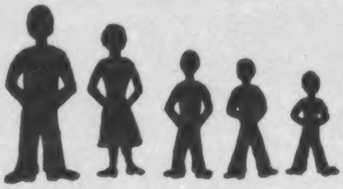

SAFE
no filth
above
SAFE
capped
and
cased
SAFE
uphill from
contamination
UNSAFE
seepage,
septic tank
to pit
UNSAFE
surface
drainage
UNSAFE
back-seepage
from impure
pond
Topsoil
Clay
Porous
Material
Water-bearing
Sand
Hardpan
Water-bearing Creviced Rock

Gen. Ag. Mech.

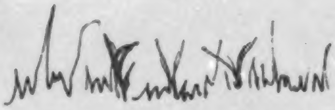
935-S-1
No. 1

DAILY WATER REQUIREMENTS

DOMESTIC USE

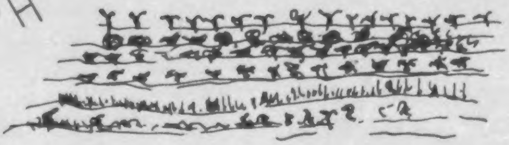


Household, 5 persons,
75 gal. per person -
375 gal. per day

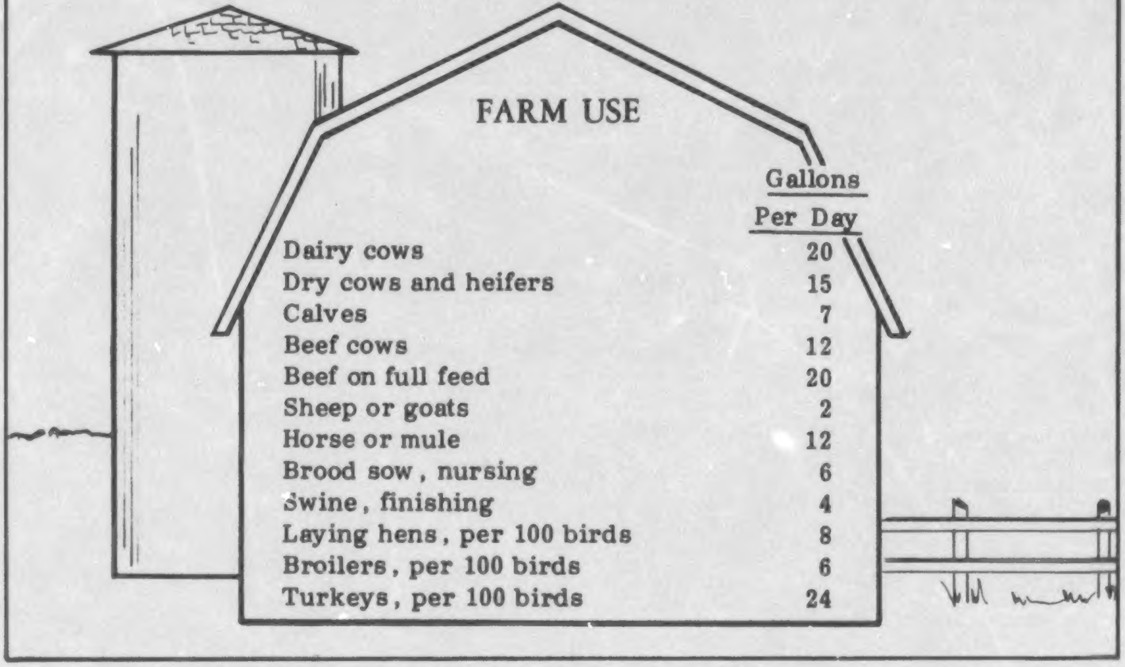


Lawn, 4,000 sq. ft.
(600 gal. per 1,000 sq. ft.) -
2,400 gal. per day

Swimming Pool Maintenance
(30 gal. per 100 sq. ft.) -
60 gal. per day



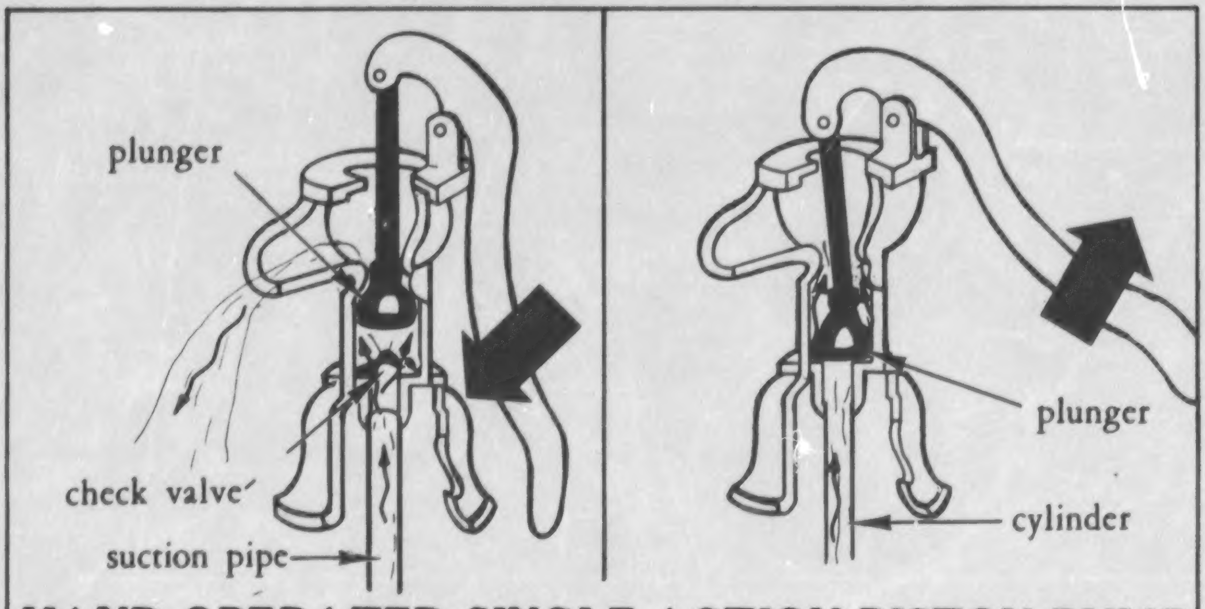
Garden, 1,000 sq. ft. - 600 gal. per day



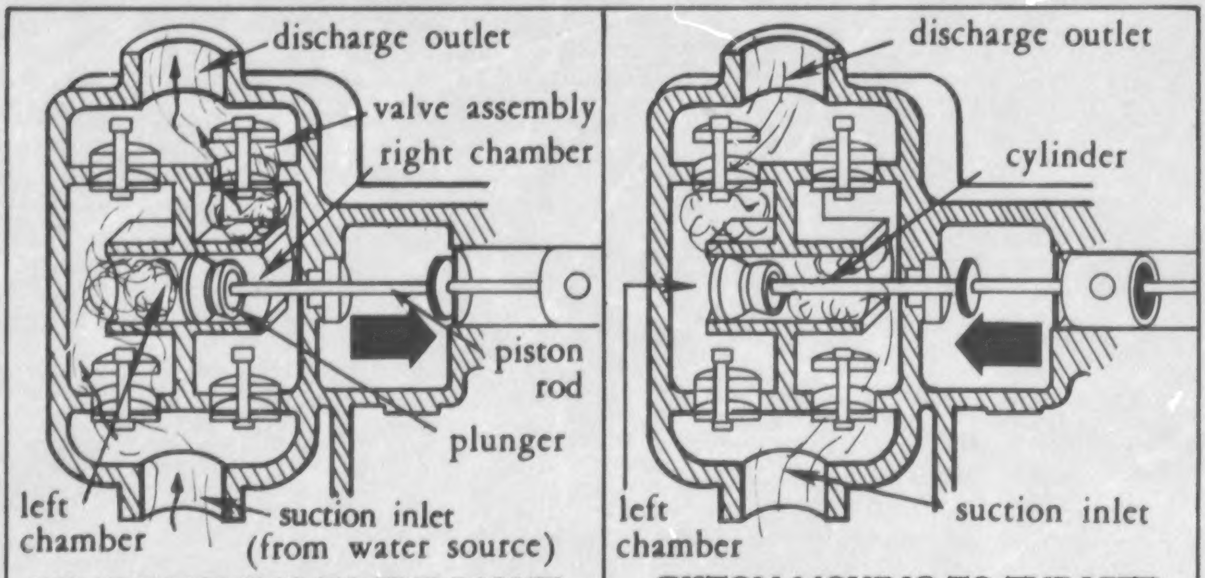
FARM USE

	Gallons Per Day
Dairy cows	20
Dry cows and heifers	15
Calves	7
Beef cows	12
Beef on full feed	20
Sheep or goats	2
Horse or mule	12
Brood sow, nursing	6
Swine, finishing	4
Laying hens, per 100 birds	8
Broilers, per 100 birds	6
Turkeys, per 100 birds	24

PISTON PUMPS


plunger
check valve
suction pipe
plunger
cylinder

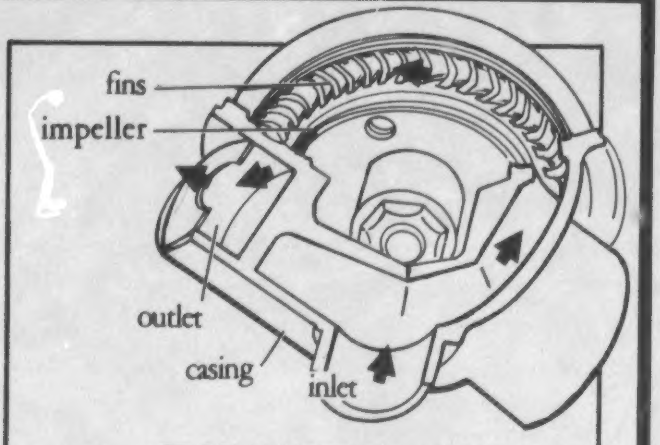
HAND OPERATED SINGLE ACTION PISTON PUMP


discharge outlet
valve assembly
right chamber
piston rod
plunger
left chamber
suction inlet (from water source)
discharge outlet
cylinder
left chamber
suction inlet

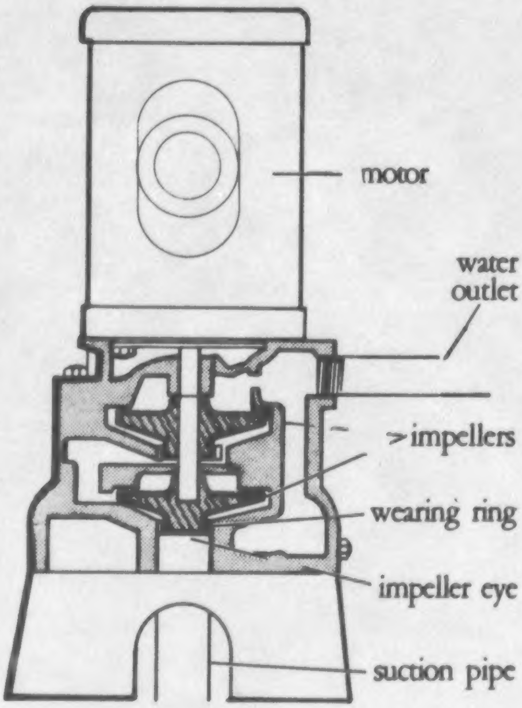
(PISTON MOVING TO THE RIGHT) (PISTON MOVING TO THE LEFT)

MOTOR DRIVEN DOUBLE-ACTION PISTON PUMP

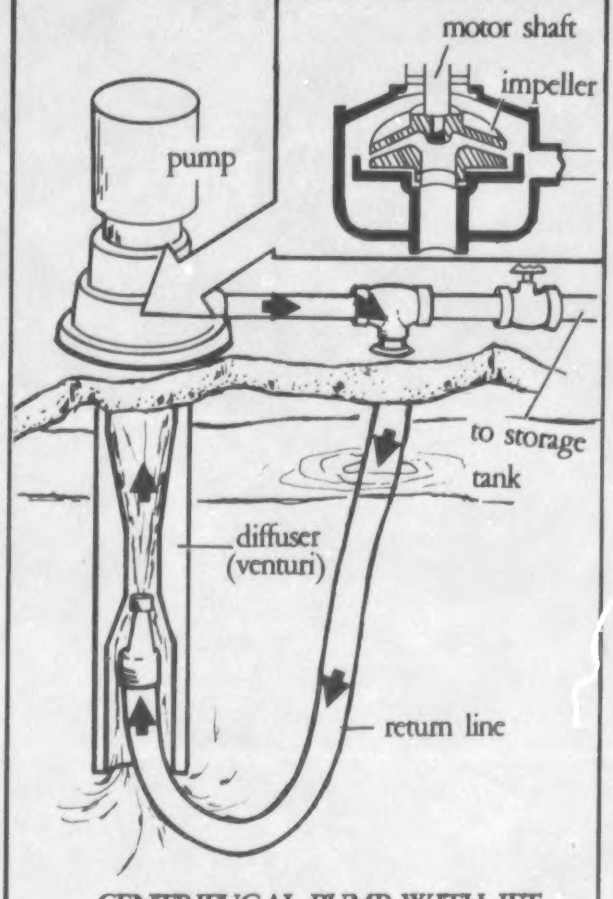
CENTRIFUGAL AND TURBINE PUMPS


fins
impeller
outlet
casing
inlet

CROSS-SECTIONAL VIEW OF TURBINE PUMP


motor
water outlet
>impellers
wearing ring
impeller eye
suction pipe

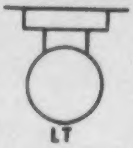
CENTRIFUGAL PUMP


motor shaft
impeller
pump
to storage tank
diffuser (venturi)
return line

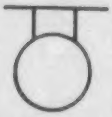
CENTRIFUGAL PUMP WITH JET

PLUMBING SYMBOLS

WATER CLOSETS

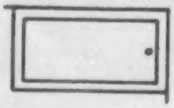


LOW TANK

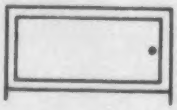


NO TANK
(FLUSH VALVE)

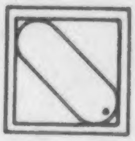
BATHS



CORNER

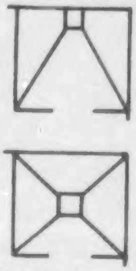


RECESSED

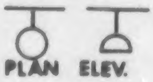


ANGLE TUB

SHOWERS

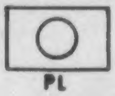


SHOWER
STALLS

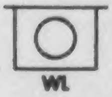


SHOWER HEAD

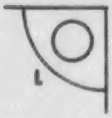
LAVATORIES



PEDESTAL

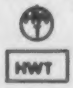


WALL



CORNER

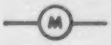
HOT WATER



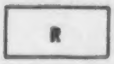
TANK

HEATER

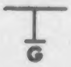
METER



GAS RANGE



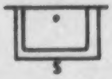
OUTLETS



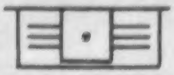
GAS

PLUMBING SYMBOLS

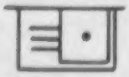
SINKS



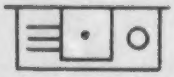
Plain Kitchen



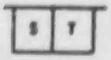
Kitchen, R&L Drain Board



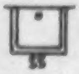
Kitchen, L. H. Drain Board



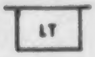
Combined Sink & Dishwasher



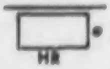
Combined Sink & Laundry Tray



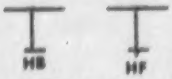
Service



Laundry Tray



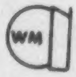
Hose Rack



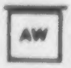
Hose Bibs or Faucet

WASHING MACHINES

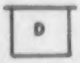
DRYERS



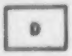
Wringer Type



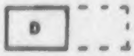
Automatic



Centrifugal

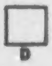


Cabinet

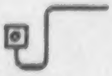


Rack

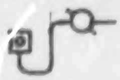
DRAINAGE SYMBOLS



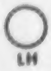
Drain



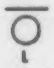
Garage Drains



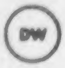
Floor Drain, with Backwater Valve



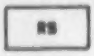
Lamp Hole Drain



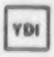
Leader Drain



Dry Well

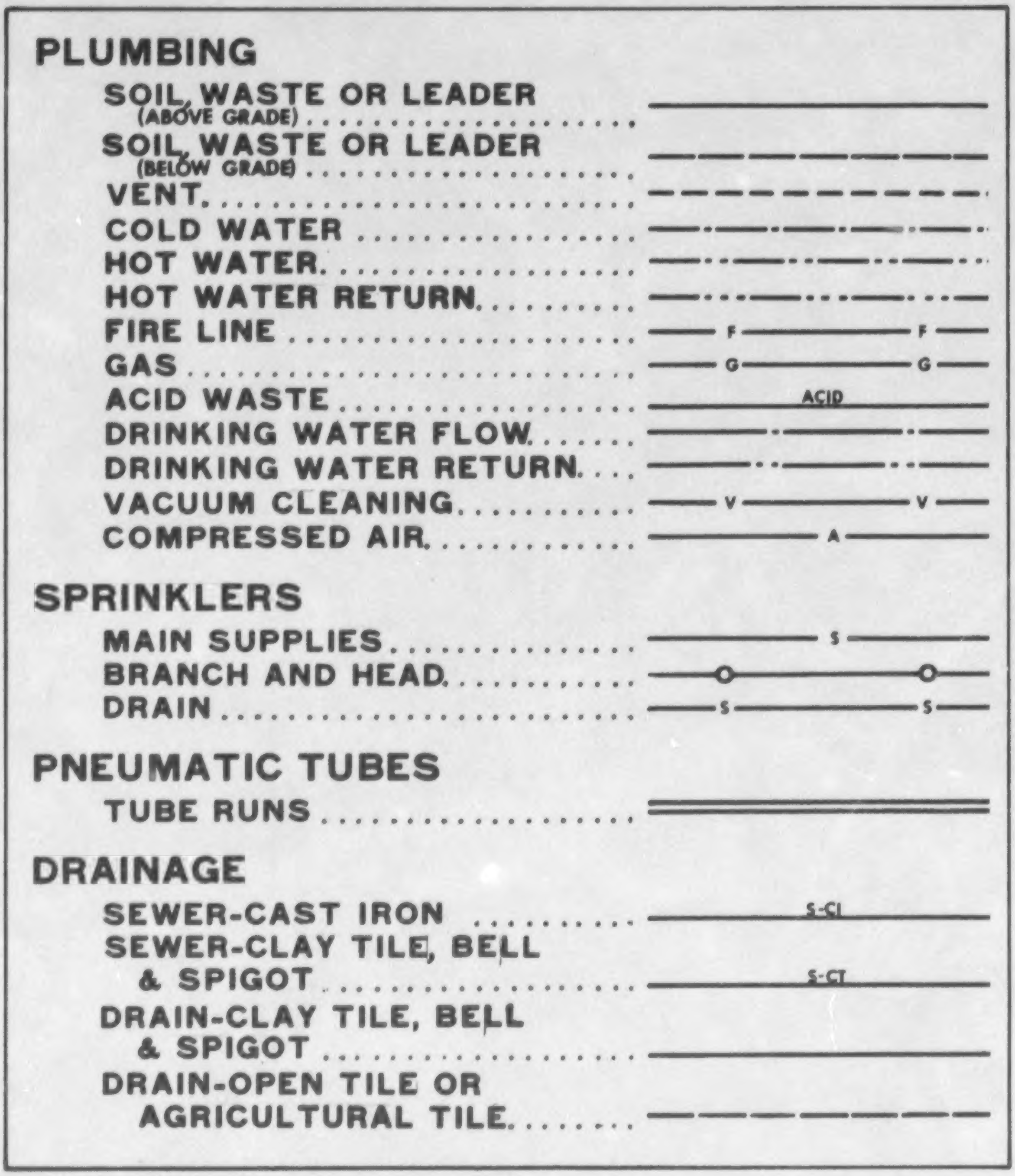


Receiving Basin



Yard Drain Inlet

PLUMBING SYMBOLS



PLUMBING

- SOIL, WASTE OR LEADER (ABOVE GRADE)
- SOIL, WASTE OR LEADER (BELOW GRADE)
- VENT
- COLD WATER
- HOT WATER
- HOT WATER RETURN
- FIRE LINE
- GAS
- ACID WASTE
- DRINKING WATER FLOW
- DRINKING WATER RETURN
- VACUUM CLEANING
- COMPRESSED AIR

SPRINKLERS

- MAIN SUPPLIES
- BRANCH AND HEAD
- DRAIN

PNEUMATIC TUBES

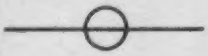
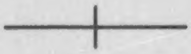
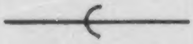
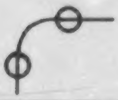
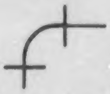
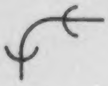
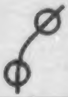
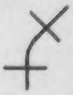
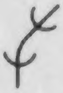
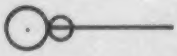
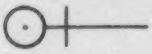
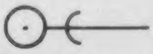
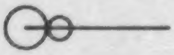
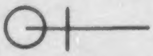
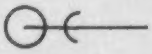
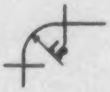
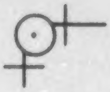
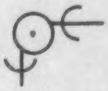
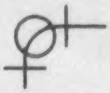
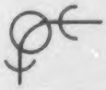
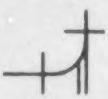
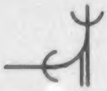
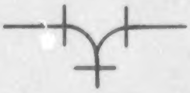
- TUBE RUNS

DRAINAGE

- SEWER-CAST IRON
- SEWER-CLAY TILE, BELL & SPIGOT
- DRAIN-CLAY TILE, BELL & SPIGOT
- DRAIN-OPEN TILE OR AGRICULTURAL TILE

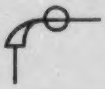
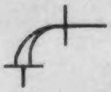
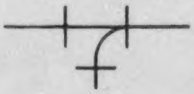
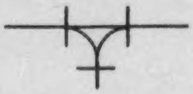
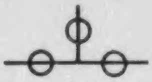
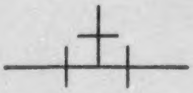
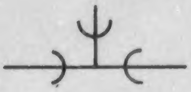
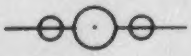
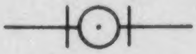
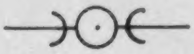
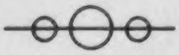
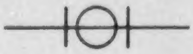
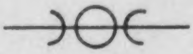
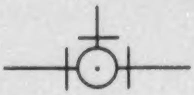
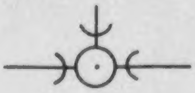
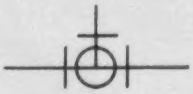
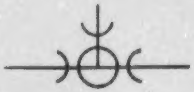
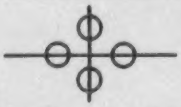
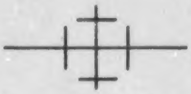
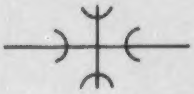
PLUMBING SYMBOLS

PIPE FITTINGS

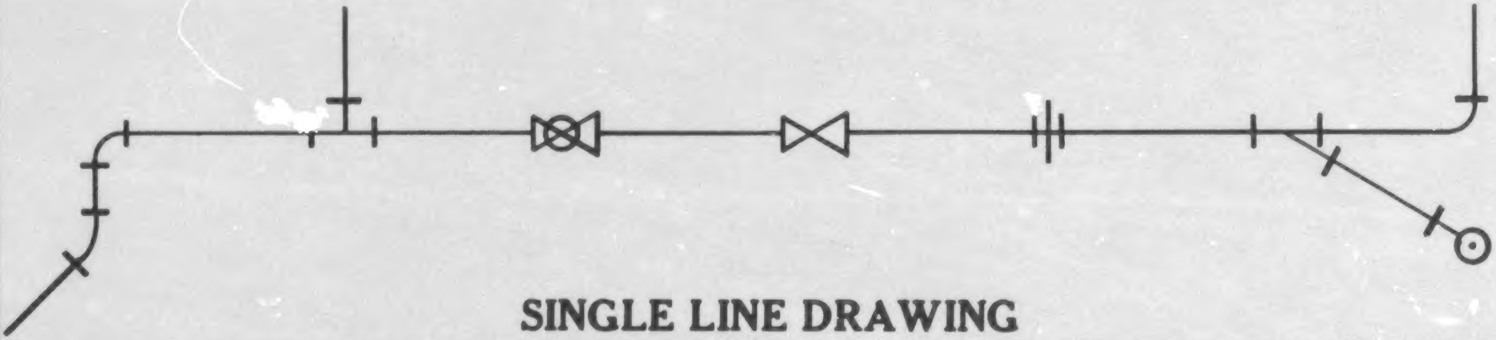
FITTING	SOLDERED	SCREWED	BELL AND SPIGOT
JOINT			
ELBOW-90°			
ELBOW-45°			
ELBOW-TURNED UP			
ELBOW-TURNED DOWN			
ELBOW-LONG RADIUS			
SIDE OUTLET ELBOW OUTLET UP			
SIDE OUTLET ELBOW OUTLET DOWN			
BASE ELBOW			
DOUBLE BRANCH ELBOW			

PLUMBING SYMBOLS

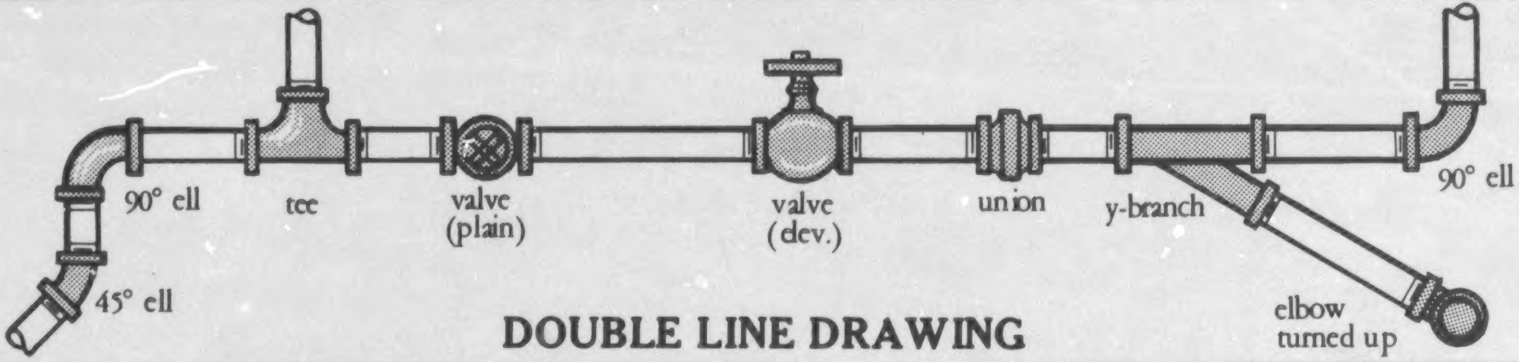
PIPE FITTINGS (cont.)

FITTING	SOLDERED	SCREWED	BELL AND SPIGOT
REDUCING ELBOW			
SINGLE SWEEP TEE			
DOUBLE SWEEP TEE			
TEE			
TEE-OUTLET UP			
TEE-OUTLET DOWN			
SIDE OUTLET TEE OUTLET UP			
SIDE OUTLET TEE OUTLET DOWN			
CROSS			

EXAMPLES OF SINGLE AND DOUBLE LINE DRAWINGS

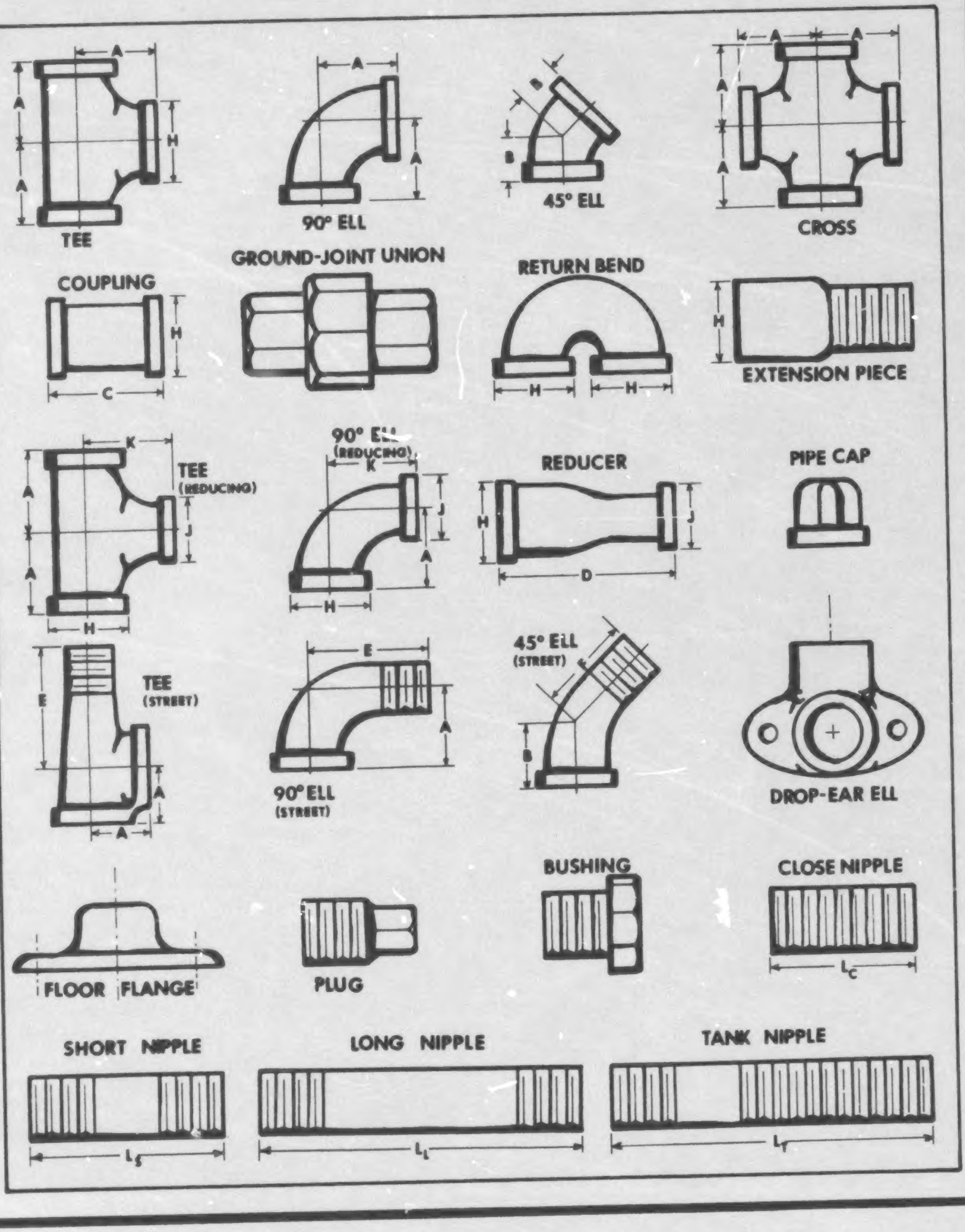


SINGLE LINE DRAWING

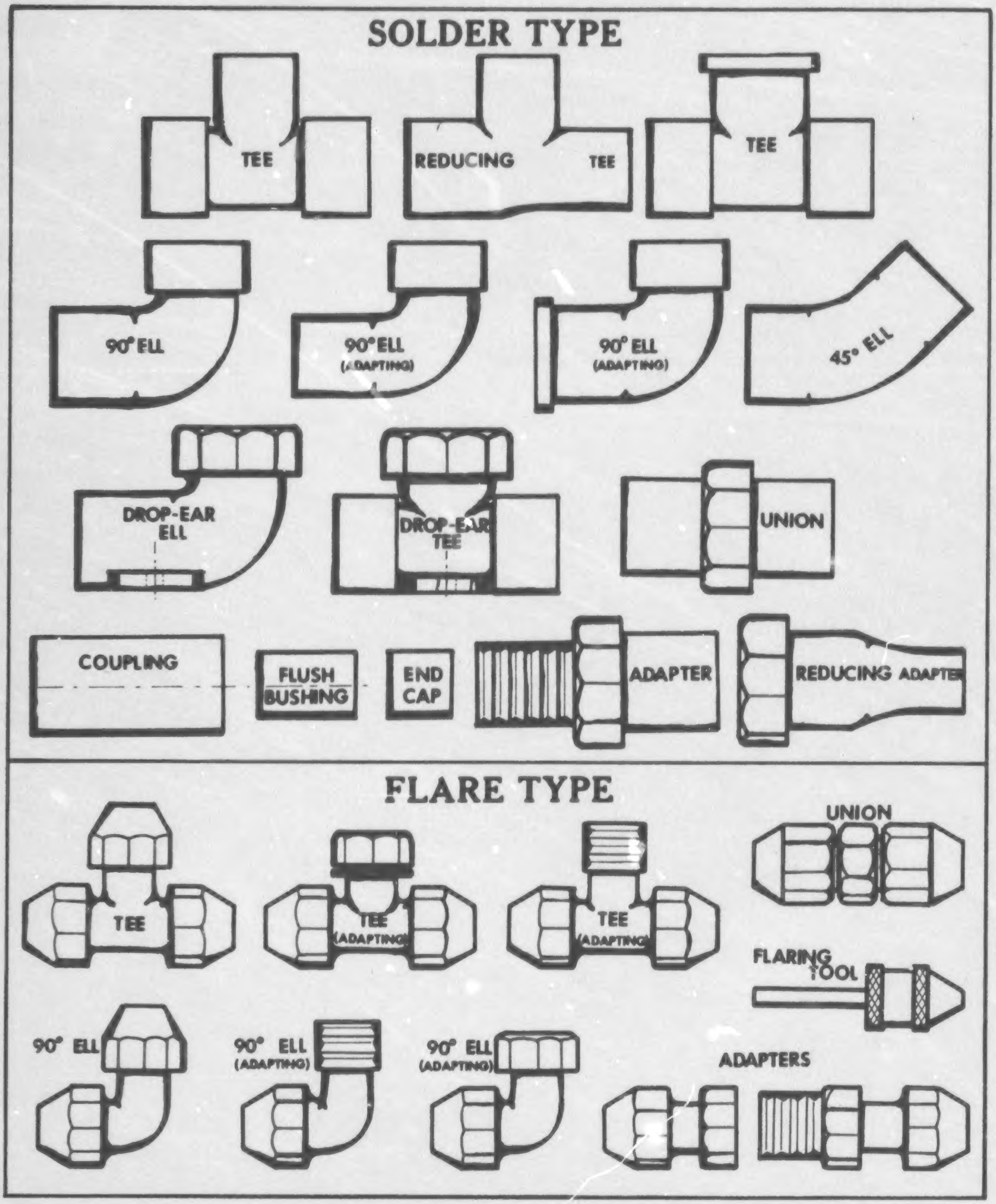

90° ell
tee
valve
(plain)
valve
(dev.)
union
y-branch
90° ell
45° ell
elbow
turned up

DOUBLE LINE DRAWING

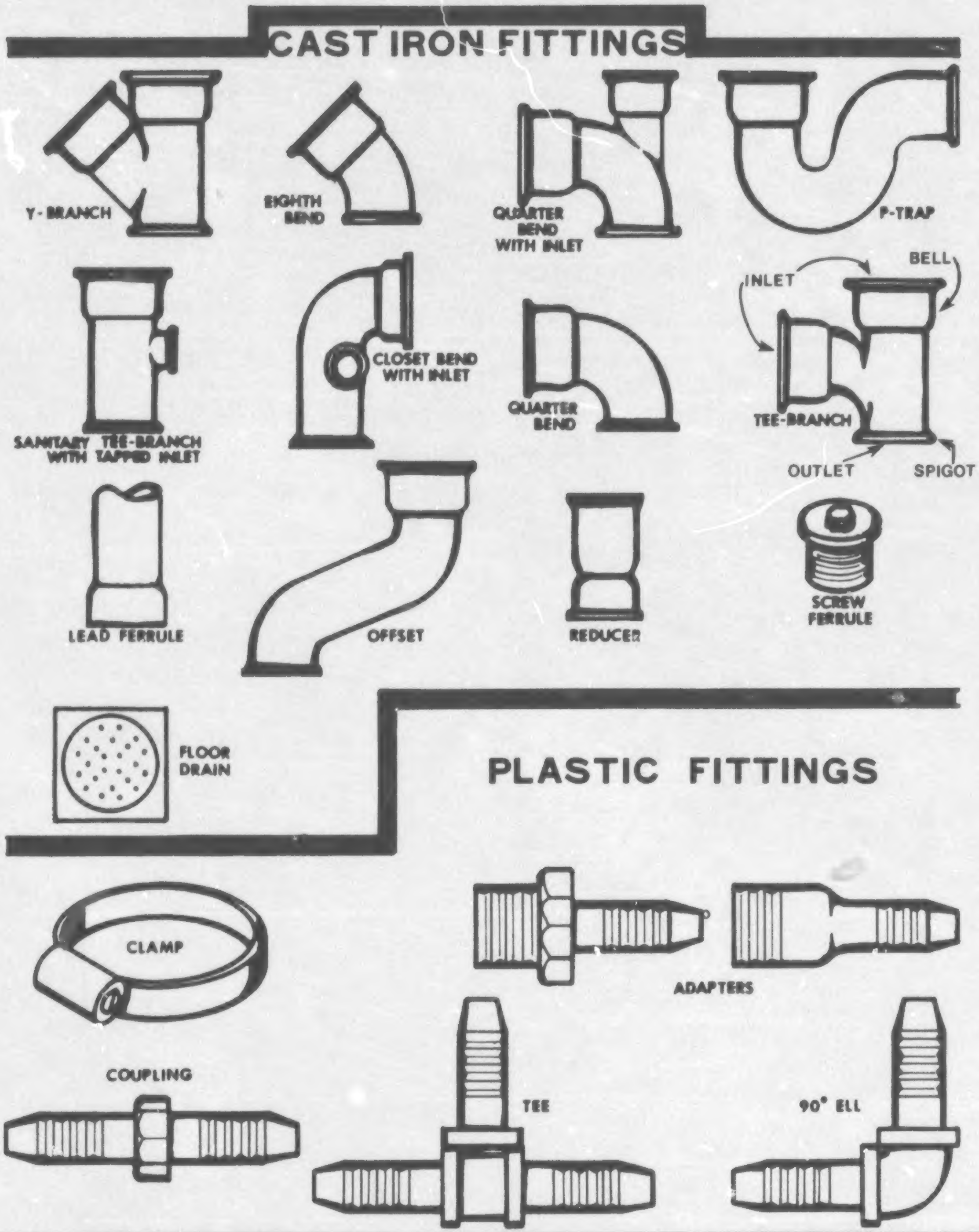
STANDARD PIPE FITTINGS


TEE
A
A
A
H
90° ELL
A
A
45° ELL
B
B
CROSS
A
A
A
A
COUPLING
H
C
GROUND-JOINT UNION
RETURN BEND
H
H
EXTENSION PIECE
H
TEE (REDUCING)
K
A
A
J
H
90° ELL (REDUCING)
K
J
A
H
REDUCER
H
J
D
PIPE CAP
TEE (STREET)
E
A
A
90° ELL (STREET)
E
A
45° ELL (STREET)
C
B
DROP-EAR ELL
FLOOR FLANGE
PLUG
BUSHING
CLOSE NIPPLE
L_C
SHORT NIPPLE
L_S
LONG NIPPLE
L_L
TANK NIPPLE
L_T

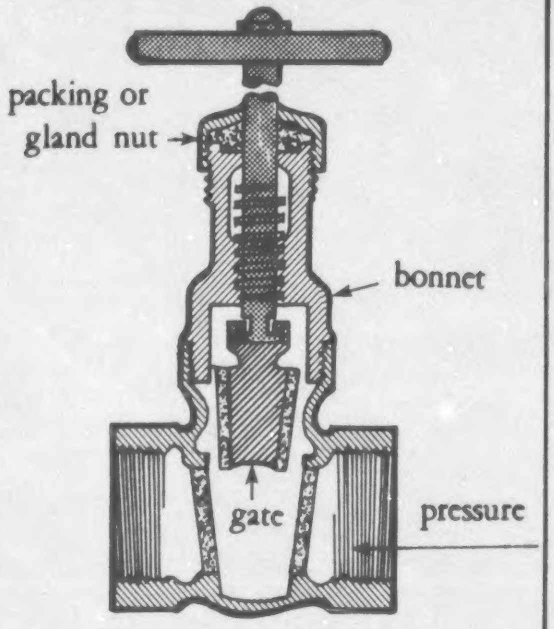
COPPER PIPE FITTINGS


SOLDER TYPE
TEE
REDUCING TEE
TEE
90° ELL
90° ELL (ADAPTING)
90° ELL (ADAPTING)
45° ELL
DROP-EAR ELL
DROP-EAR TEE
UNION
COUPLING
FLUSH BUSHING
END CAP
ADAPTER
REDUCING ADAPTER
FLARE TYPE
TEE
TEE (ADAPTING)
TEE (ADAPTING)
UNION
FLARING TOOL
90° ELL
90° ELL (ADAPTING)
90° ELL (ADAPTING)
ADAPTERS

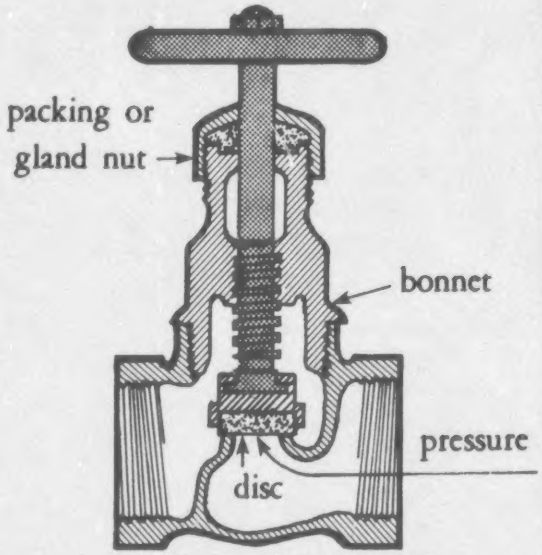
KINDS OF PIPE FITTINGS


CAST IRON FITTINGS
Y-BRANCH
EIGHTH BEND
QUARTER BEND WITH INLET
P-TRAP
SANITARY TEE-BRANCH WITH TAPPED INLET
CLOSET BEND WITH INLET
QUARTER BEND
INLET
BELL
TEE-BRANCH
OUTLET
SPIGOT
LEAD FERRULE
OFFSET
REDUCER
SCREW FERRULE
FLOOR DRAIN
PLASTIC FITTINGS
CLAMP
ADAPTERS
COUPLING
TEE
90° ELL

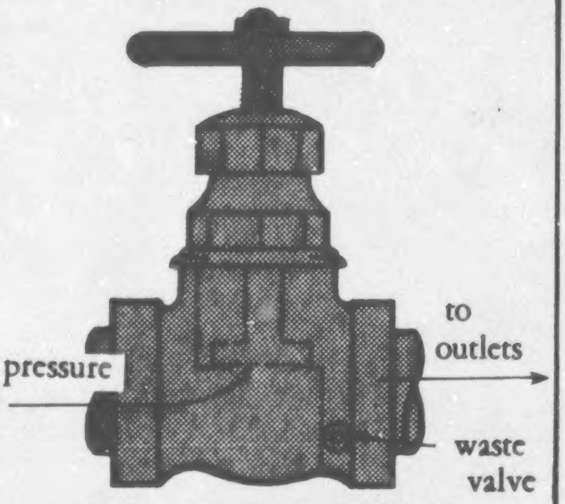
KINDS OF VALVES


packing or
gland nut
bonnet
gate
pressure

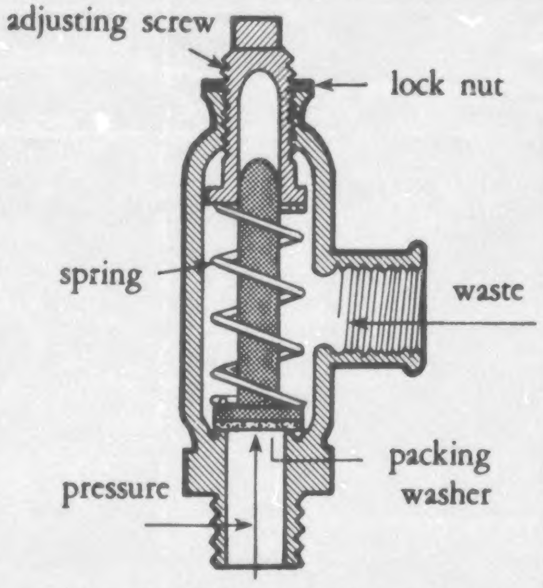
GATE VALVE


packing or
gland nut
bonnet
pressure
disc

GLOBE VALVE


pressure
to
outlets
waste
valve

WASTE VALVE

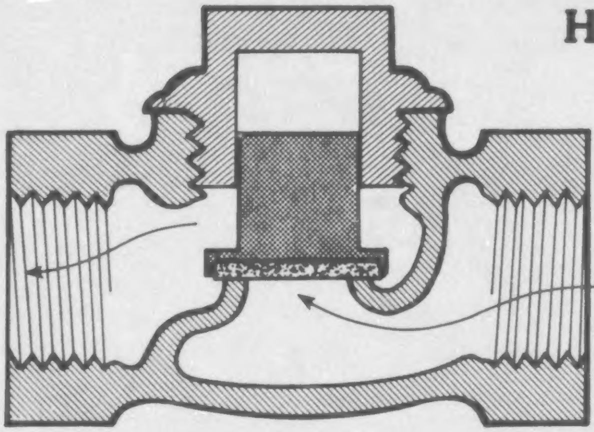

adjusting screw
lock nut
spring
waste
packing
washer
pressure

SAFETY VALVE

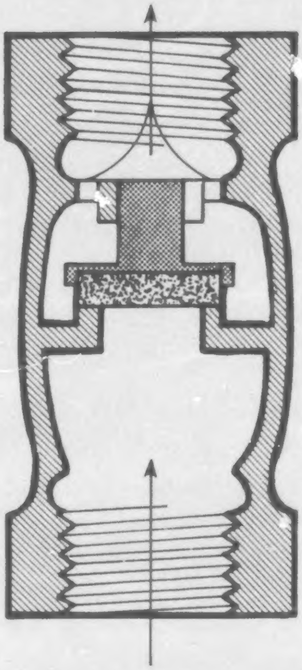
KINDS OF VALVES

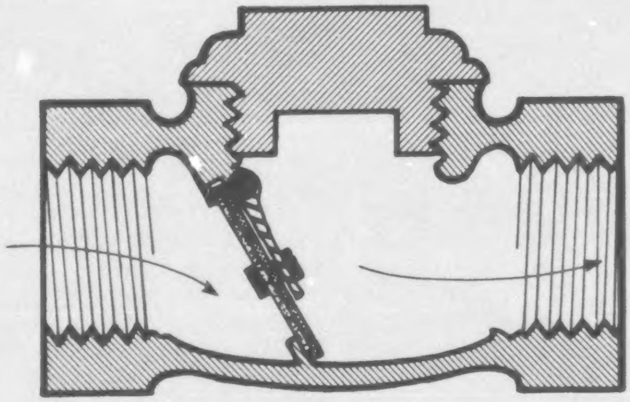
CHECK VALVES

HORIZONTAL CHECK



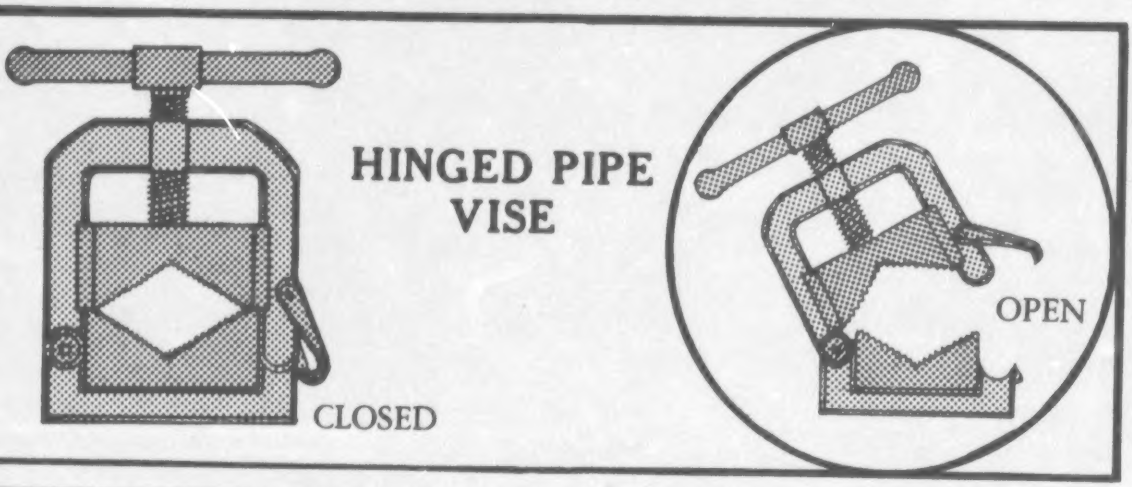
VERTICAL CHECK



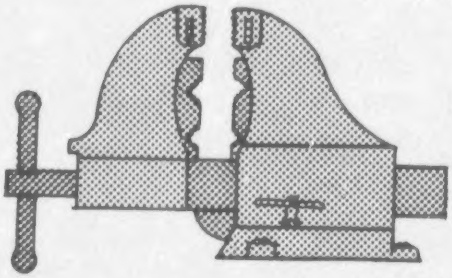


SWING CHECK

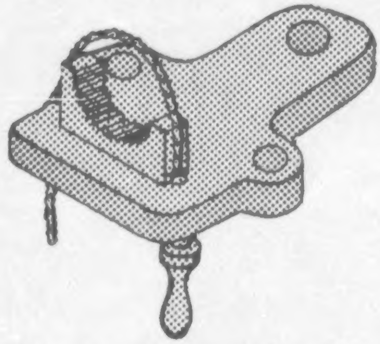
PLUMBING TOOLS



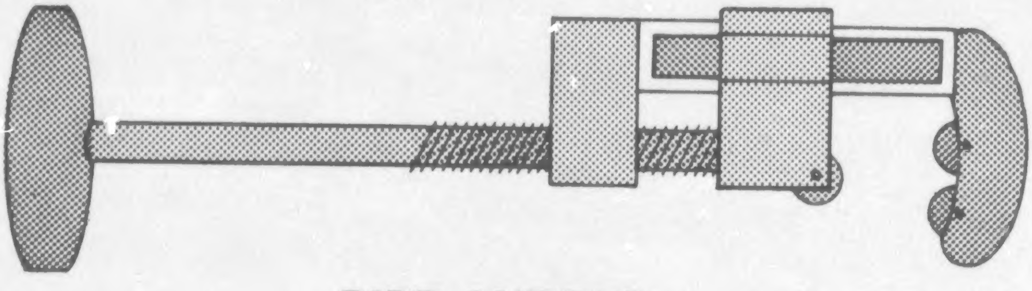
HINGED PIPE VISE



COMBINATION PIPE VISE

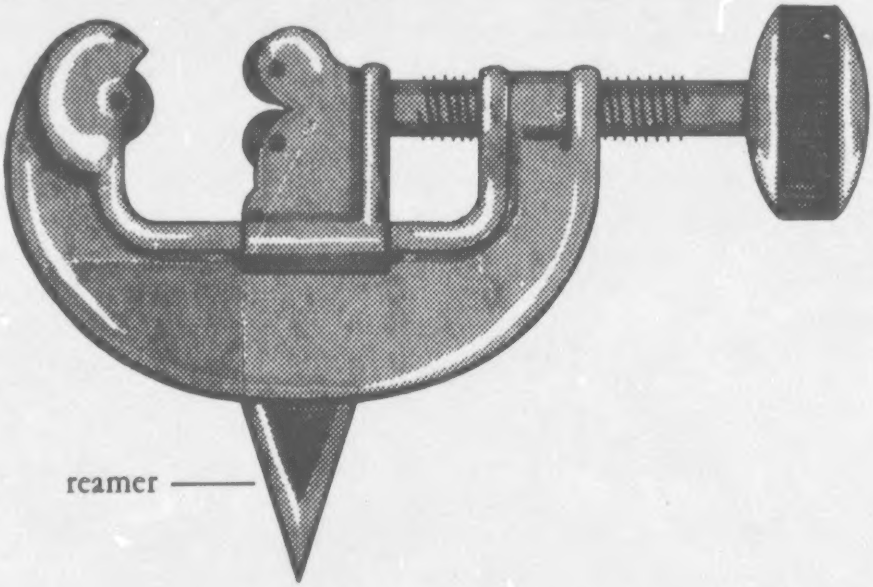


CHAIN PIPE VISE

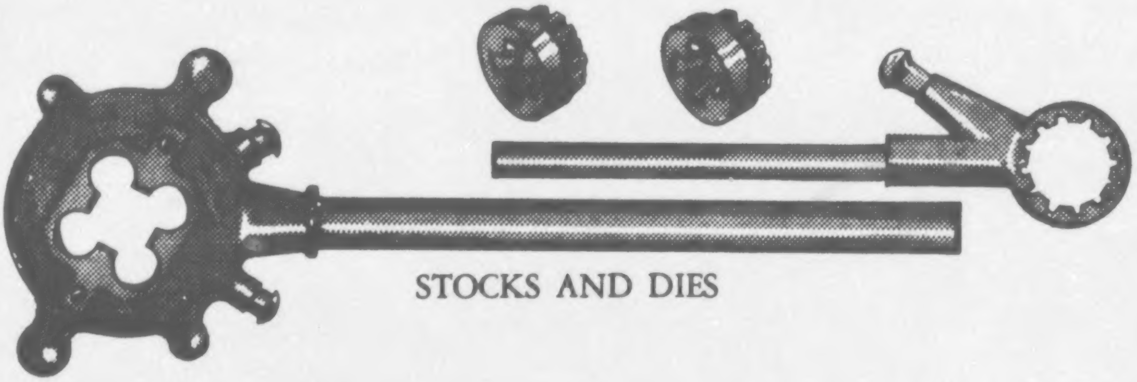


PIPE CUTTER

PLUMBING TOOLS

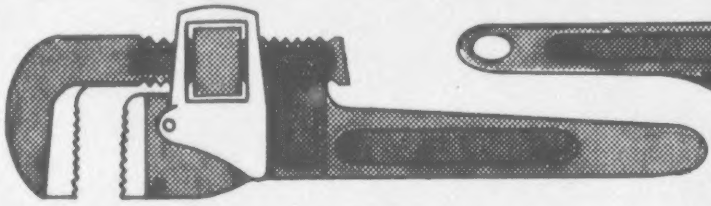


TUBE CUTTER

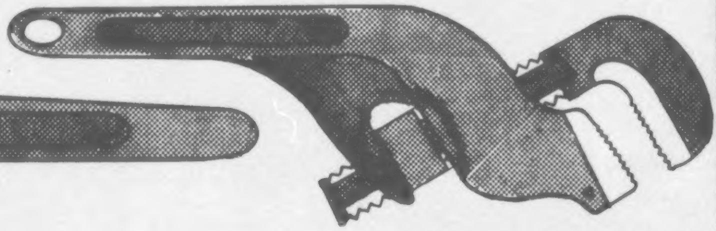

STOCKS AND DIES

PIPE THREADERS

PLUMBING TOOLS



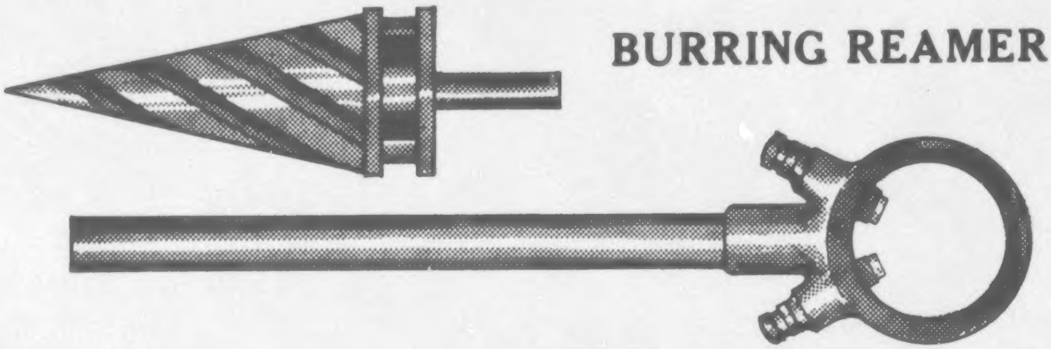
sizes 6 to 48 inches

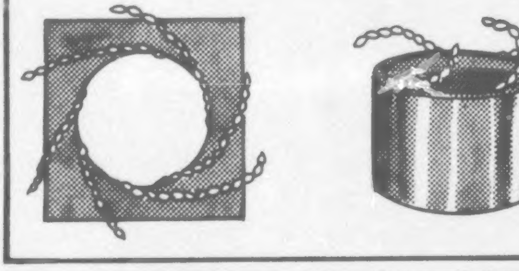


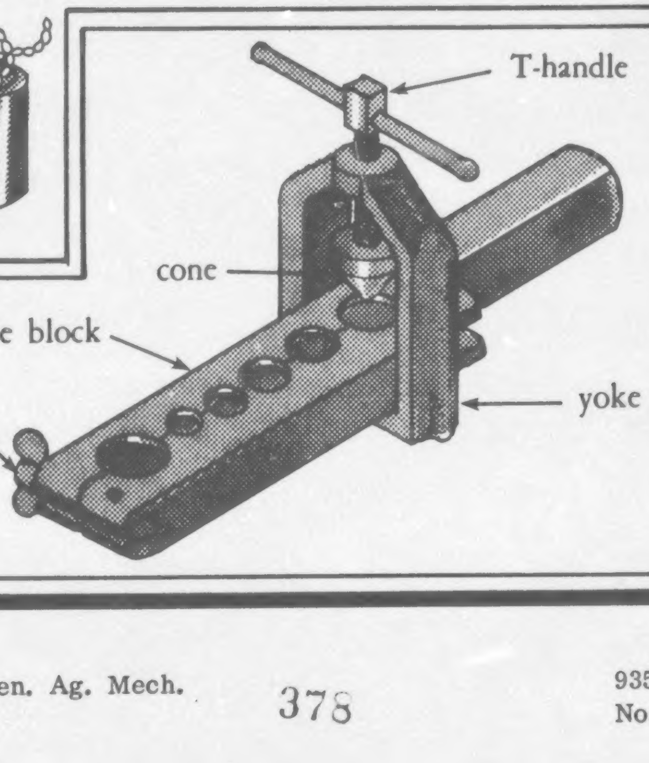
sizes 6 to 36 inches

PIPE WRENCHES

BURRING REAMER

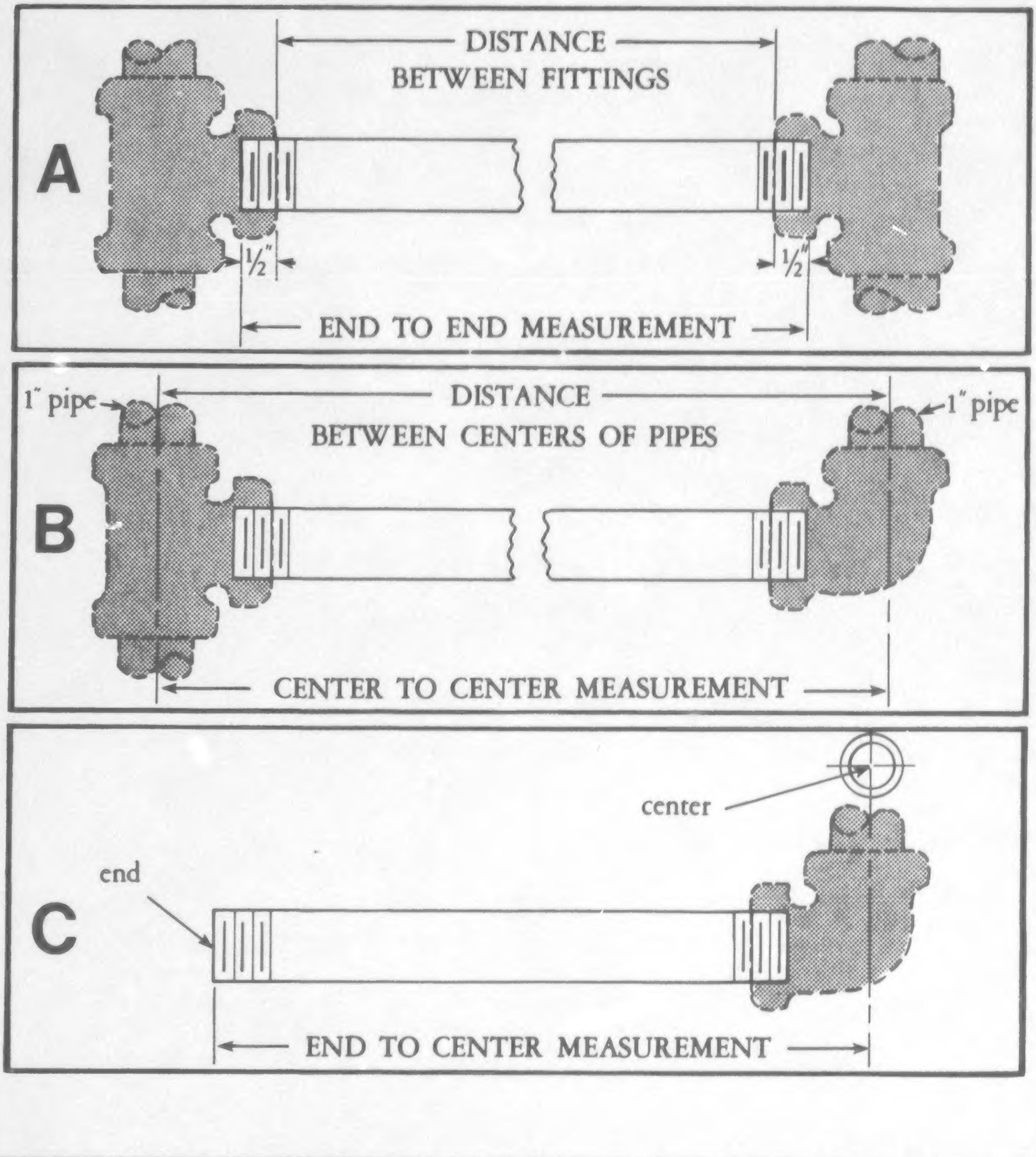




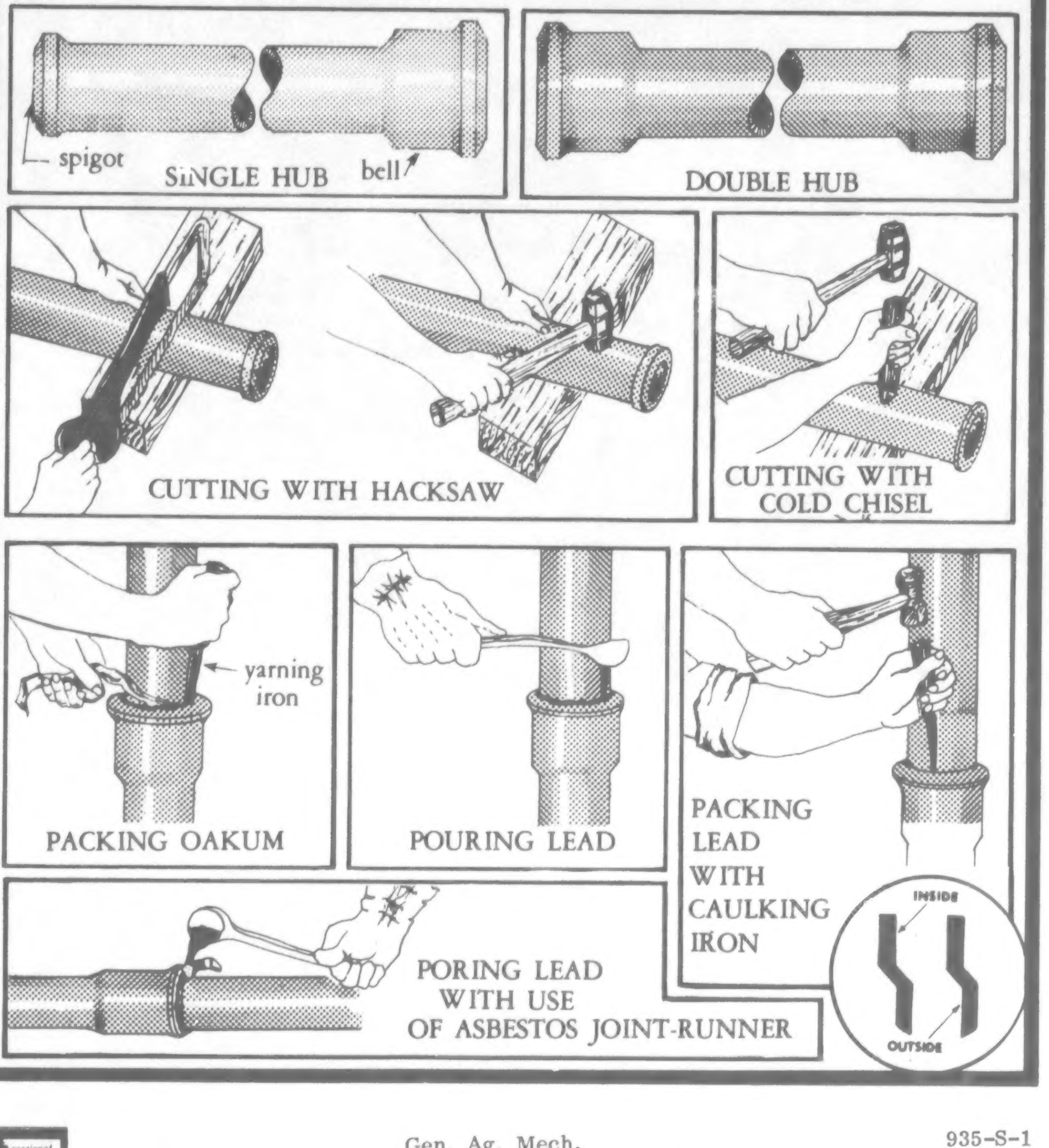

T-handle
cone
die block
clamp
yoke

FLARING TOOL

MEASURING PIPE


A
DISTANCE BETWEEN FITTINGS
½"
½"
END TO END MEASUREMENT
B
1" pipe
DISTANCE BETWEEN CENTERS OF PIPES
1" pipe
CENTER TO CENTER MEASUREMENT
C
center
end
END TO CENTER MEASUREMENT

CUTTING AND ASSEMBLING CAST IRON SOIL PIPE



SINGLE HUB

DOUBLE HUB

CUTTING WITH HACKSAW

CUTTING WITH COLD CHISEL

PACKING OAKUM

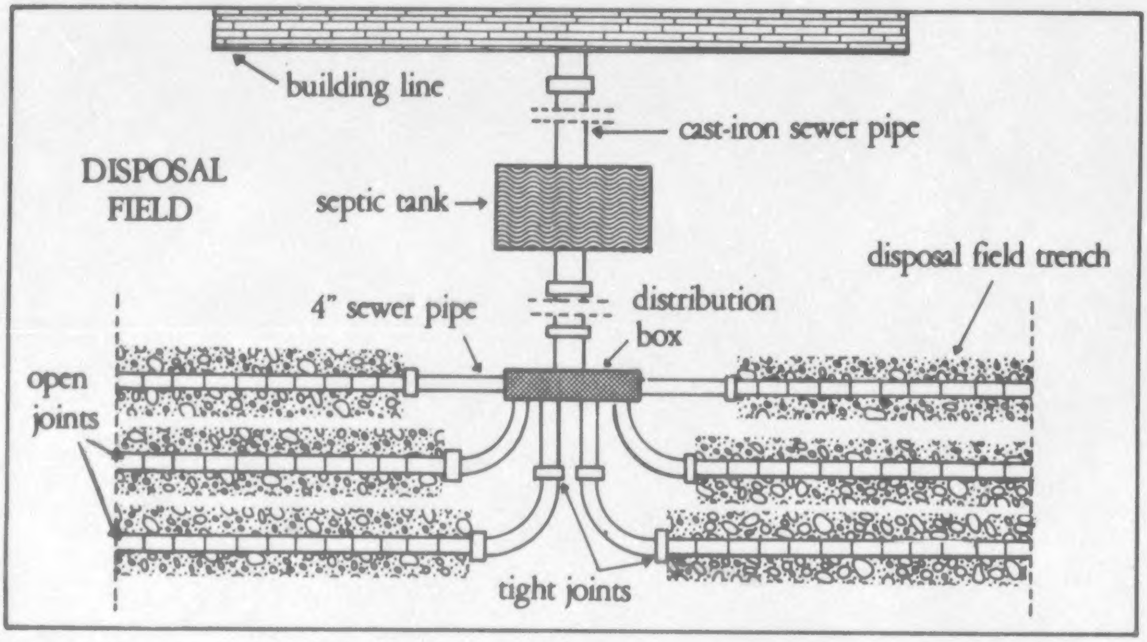
POURING LEAD

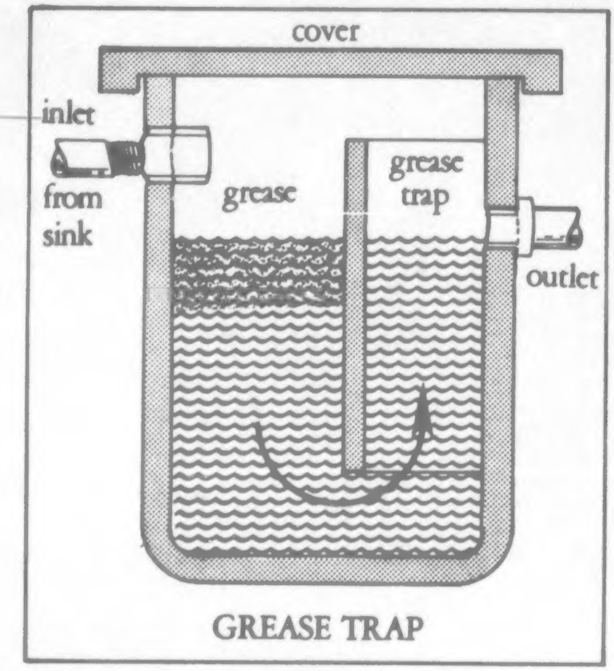
PACKING LEAD WITH CAULKING IRON

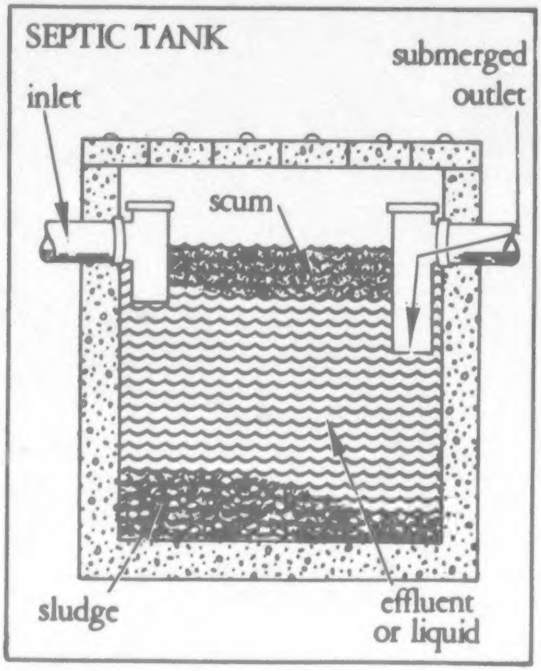
PORING LEAD WITH USE OF ASBESTOS JOINT-RUNNER

spigot
bell
yarning iron
INSIDE
OUTSIDE

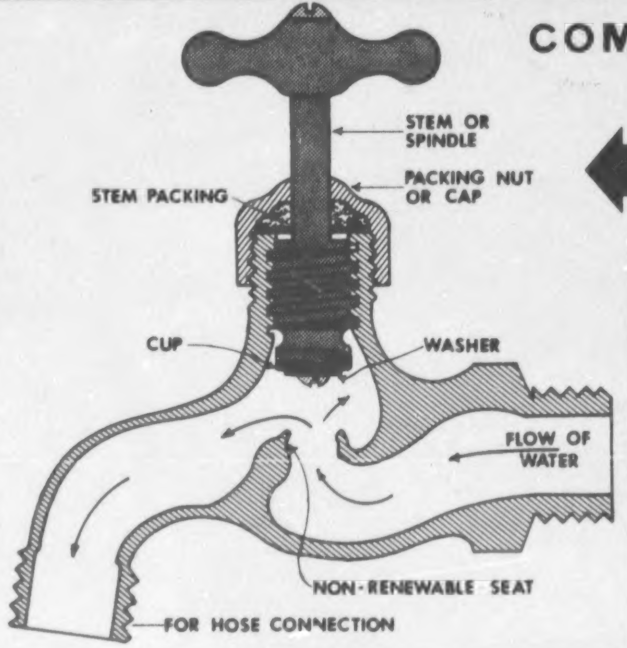
SEWAGE DISPOSAL


DISPOSAL FIELD
building line
cast-iron sewer pipe
septic tank →
disposal field trench
4" sewer pipe
distribution box
open joints
tight joints


cover
inlet
from sink
grease
grease trap
outlet
GREASE TRAP

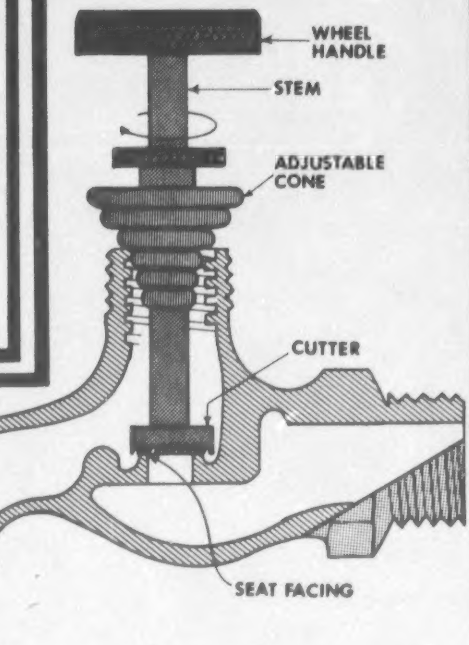

SEPTIC TANK
submerged outlet
inlet
scum
sludge
effluent or liquid

FAUCET AND SEAT DRESSER

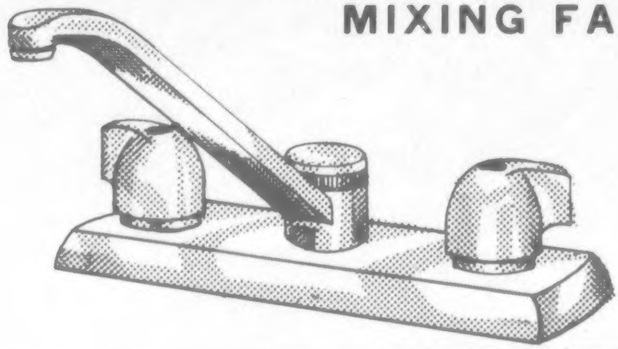

STEM OR SPINDLE
PACKING NUT OR CAP
STEM PACKING
CUP
WASHER
FLOW OF WATER
NON-RENEWABLE SEAT
FOR HOSE CONNECTION

COMPRESSION TYPE FAUCET

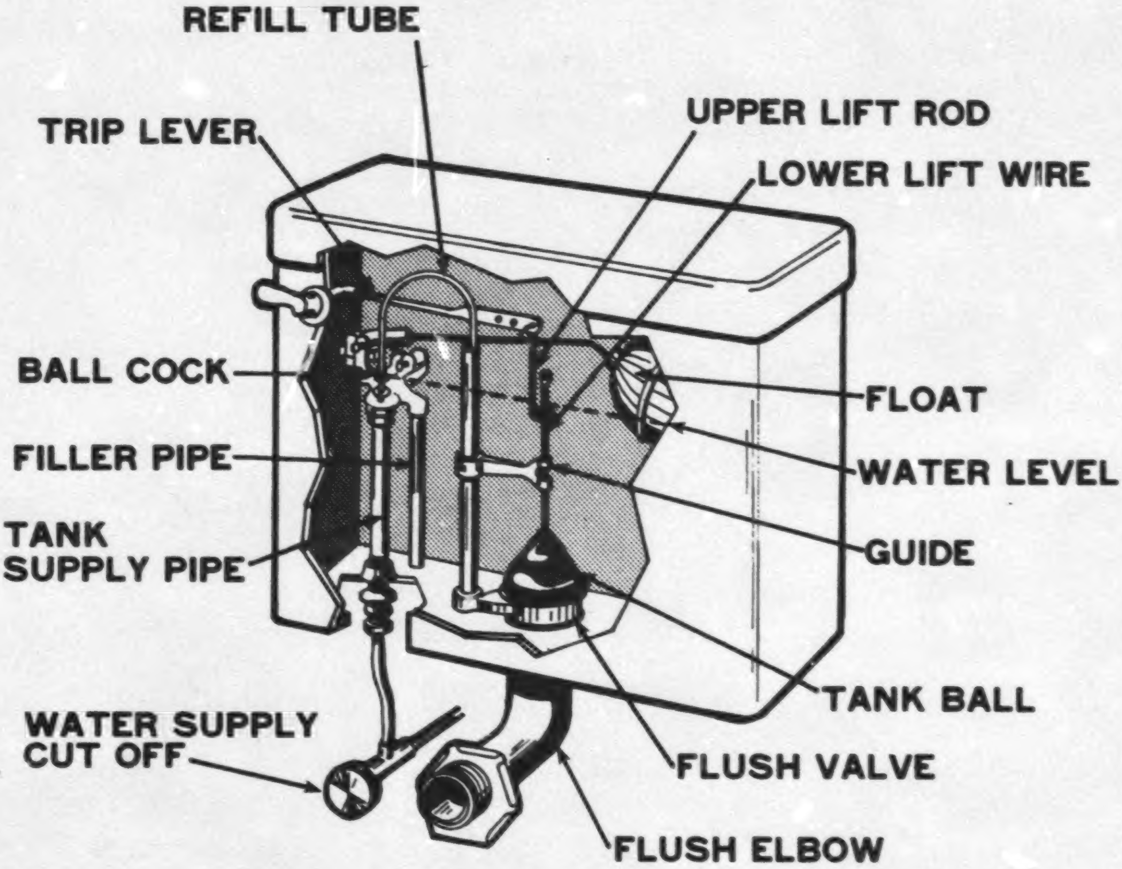
FAUCET SHOWING SEAT BEING REFACED


WHEEL HANDLE
STEM
ADJUSTABLE CONE
CUTTER
SEAT FACING

MIXING FAUCET



COMMODE


REFILL TUBE
TRIP LEVER
UPPER LIFT ROD
LOWER LIFT WIRE
BALL COCK
FLOAT
FILLER PIPE
WATER LEVEL
TANK
SUPPLY PIPE
GUIDE
TANK BALL
WATER SUPPLY
CUT OFF
FLUSH VALVE
FLUSH ELBOW

GENERAL AGRICULTURAL MECHANICS

Unit T: Farm and Ranch Surveying

Topic 1: The Use of the Level in Land Management

Suggested Procedures and Activities: A number of laboratory exercises may be conducted from the information presented in the topic. It is suggested that the teacher conduct a number of the exercises in order to give the students practice in using the level and tripod.

1. Kinds of Tripod Levels

There are several kinds of tripod levels which vary considerably in quality, cost, and accuracy. The most common types of tripod levels are the wye, dumpy, architect, drainage, and farm level.

The wye level is the most expensive and gets its name from the method used to attach the telescope to the rest of the level. The telescope, attached by two wyes, may be easily removed and adjusted. This level may have either three or four leveling screws.

The dumpy level has a bubble tube attached to the telescope which is difficult to remove from the rest of the level. It is cheaper and easier to adjust than the wye and may have either three or four leveling screws.

The architect and drainage levels are similar to the dumpy and have plumb bob attachments (an attachment used to mark a point).

The farm level is also similar to the dumpy level. It is adequate for most farm jobs, inexpensive, simple to use, accurate, and with proper care will give excellent service. The two types of farm levels are the turret and the utility. The turret type has three leveling screws, while the utility type has four leveling screws.

2. Transporting the Tripod Level

A level must be handled and transported properly if it is to be accurate and give service. Suggestions for handling and transporting a level are as follows:

1. The level should be protected from shock and vibration;
2. The level should be kept in its box except when it is being used;
3. The level should be screwed firmly and with care when fastening it to the tripod.

4. The level and tripod should be carried on the shoulder except when walking through brush, then it should be carried under the arm;
5. The moving parts should never be forced;
6. The leveling screws should be snug against the leveling plate;
7. The lens on some levels should be protected from the direct rays of the sun by using a sun shade;
8. The lens should be cleaned with a soft cloth or tissue;
9. The lens should not be removed from the telescope; and
10. The tripod nuts should be loosened before picking the instrument up or setting it down.

3. Checking and Adjusting the Level

A vocational agriculture student should become familiar with the different parts before using the level. These are shown in the following transparency.

Transparency No. 1

The following steps should be used in setting up the level:

1. The tripod legs should be set firmly and at least 3 1/2 feet apart;
2. The wing nuts should be tightened on the tripod head;
3. The level should be securely screwed to the tripod head;
4. One of the tripod legs should be spiked firmly in the ground;
5. The telescope should be turned over the spiked leg and one of the other legs, and the second leg should be spiked and moved in or out until the bubble is visible in the bubble tube;
6. The level tube is turned over the third leg, and it is spiked and moved in or out until the bubble is visible in the bubble tube.
7. The leg nuts should be tightened on the tripod legs.

Before leveling the instrument, the leveling screws are placed in the mid position in the bosses. This places the center spring under light tension and allows the screws to be raised or lowered as needed. The turret should turn freely.

Leveling the Turret Type Level - The steps in leveling the turret type level are as follows:

1. The telescope is placed over two of the leveling screws, and the bubble is centered by turning the leveling screws equal distances in opposite directions. This may be accomplished by moving the thumbs toward or away from each other.

2. The telescope is set directly over the third screw, and the bubble is centered by turning the third screw.
3. The leveling process is repeated in each of the above steps until the bubble remains centered in the bubble tube.

Leveling the Utility Type Level - The procedure is as follows:

1. The telescope is placed over two diagonally opposite leveling screws, and the bubble is centered by turning the screws equal distance in opposite directions. The thumbs should be moved toward or away from each other.
2. The telescope is turned over the other two diagonally opposite leveling screws, and the bubble is centered.
3. The leveling process is repeated in each of the above positions until the bubble remains centered in the bubble tube.

The farm level should be checked for accuracy each time before it is used. The parts that should be checked are the bubble tube, telescope, and cross-hairs. The turret type and utility type levels are checked in the same manner.

Bubble Tube - The bubble tube is checked as follows:

1. The bubble tube is placed over two of the leveling screws, and the screws are turned in or out until the bubble comes exactly between two corresponding vial lines.
2. Then the turret is swung 180 degrees so that the bubble tube is end for end from the first position. If the bubble does not come exactly to the center between the vial lines as at first, one-half of the amount is corrected by the same two leveling screws. The other half of the difference should be adjusted by the level vial screws shown in the transparoncy.

The three screws that hold the turret in place should be screwed out to remove the turret and telescope.

Transparency No. 2

The bottom screws on the low end of the tube are loosened and the top screws are tightened. The test and adjustment should be repeated until the bubble stands between the vial lines regardless of the direction the level vial tube is turned. The bubble tube on the utility level is adjusted with two vial screws shown in transparency.

Telescope - There are two tests that should be conducted on the telescope. One is testing the telescope by inverting the turret, and the other is by testing to see if the line of sight is level when the bubble is centered. The first test is made after the instrument is leveled by focusing the telescope on a definite spot 200 to 300 feet in the distance with the turret in the correct position. The turret is then inverted and a sight is taken on the spot. If the center of the horizontal cross-hair remains on the spot, it is properly adjusted. If the telescope needs adjusting, the small screws at the front (where the telescope goes through the turret) should be adjusted to eliminate half of the error. The process should be repeated until the reading remains the same with the turret in the correct position and in the inverted position.

The second test (a test to see if the telescope is in the line of sight of the level when the bubble is centered) is conducted as follows:

1. Stakes A and B are driven in the ground 100 feet apart, or some other convenient distance. In the same line but in the opposite direction, Stake C is driven in the ground. The distance between AC and AB should be equal, and the tops of Stakes B and C should be set at the same level.
2. The instrument is set over Stake A and the rod is held on Stake B. The target rod should be adjusted so that the horizontal cross-hair bisects the target.
3. The target setting is read and recorded.
4. The target setting is not changed, and the rod is moved to Stake C.
5. Stake C is moved up or down until the cross-hair bisects the target when the rod is held on Stake C and the bubble is in the center of the tube. If it is necessary to raise the stake, it should be pulled up too far and gradually driven into the ground until it is the correct elevation. The accuracy of the test depends on the stakes being at the same level.
6. Then the instrument should be moved to within three or four inches of Stake B and leveled.
7. The rod then is set on top of Stake B, and the target is adjusted until the cross-hairs bisect the target.
8. Then the target rod is left at this setting and carried to Stake C where it is placed on top of Stake C, and a reading is taken. If the cross-hairs bisect the target, the line of sight is level when the bubble is centered. If the cross-hairs do not bisect the target, the telescope should be adjusted by the screws at the front of the level frame. The front end of the telescope is raised by unscrewing the bottom screw and tightening the top screw. The telescope is lowered by moving the screws in the opposite direction.

Testing the Cross-Hair - The cross-hairs are tested after the instrument is leveled and the telescope is adjusted, which is accomplished by moving the slide tube in or out until the object comes in focus. The horizontal cross-hair is focused on a definite point, and the level is rotated back and forth slightly from side to side. If the ends of the cross-hair remain on the point in the same place as the center, the cross-hair is in adjustment. If the cross-hair is out of adjustment, the instrument should be sent to the company to have it adjusted.

4. Using the Target Rod

Three types of target rods are the Philadelphia, architect, and self reading rod.

Transparency No. 3

The Philadelphia rod is graduated in feet, tenths, and hundredths; and the architect rod has the same graduations, but it is much lighter and shorter. The self-reading rod is graduated in feet, tenths, and hundredths and is used principally for surveying land, running drainage lines, and general soil conservation work.

The Philadelphia and architect target rod have extensions. The target must be set at the same reading on the face of the rod before it is extended to equal the lowest reading on the back of the extended rod. The target should always represent a true reading and should be raised to the top of the unextended rod section before the rod is lengthened. The target rod has very few parts, but a student should become familiar with the parts and their function if he is to use the rod properly.

The rod is used to measure elevation or comparative heights of objects in their relation to the height of the instrument. For example, a rod reading of three feet at one point and five feet at another point is a difference in elevation of two feet at these two points. Grades are established by moving the target a distance over the ground. The grade is raised when the target is lowered, and the grade is lowered when the target is raised.

Instructions to Rodman - To hold the rod, the rodman stands behind the rod and holds it in a vertical position. If the rod is allowed to lean in any direction, the reading will be inaccurate. The rod is usually held by the left hand, and the target is moved by the right hand.

The rodman should place the rod on firm ground before a reading is taken by the man operating the instrument. The rod should not be placed in a depression or on a large clod of dirt to get a reading. In freshly plowed land, the rod should be placed on a foot print that has had a man's weight on it.

When the rodman is too far from the instrument, it is necessary that hand signals be used. The following transparency shows some hand signals that may be used.

1. The instrument is set up at some convenient distance away from BM-1 and in the direction of BM-2. The distance will depend on the accuracy of the instrument and should not exceed 350 feet. If possible the instrument should be located near the center of two readings, BM-1 and TP-1 for example.
2. A reading is taken and recorded on BM-1. This is 3.02, as shown in transparency. This reading is known as a backsight (BS), which is a reading taken on a point of known elevation. BS readings are also known as plus sights because they are added to the elevation of the last known point to give the elevation of the line of sight, called height of instrument (HI). The HI at BM-1 is 103.02 (100.00 + 3.02).
3. The next reading is taken at TP-1 where a temporary stake is set. The instrument is not moved to take this reading, which is called a foresight (FS) reading. A FS reading is taken at a point of unknown elevation and is called a minus sight since it is subtracted from the HI to give the elevation at the new point. The elevation or HI at TP-1 in transparency is 99.34 (103.02 - 3.68). TP-1 now has a known elevation and can be used when the instrument is moved.
4. The readings are made as explained above.

The survey should be continued until a circuit is completed, as is shown in Transparency No. 7; and the last FS is taken at BM-1. This is necessary to check the accuracy of the survey.

The final reading in most cases will not be exactly the same as the 100.00 feet which was used at the start. If there is a difference between the original reading and the last reading, this indicates an error. A reasonable allowance can be made for errors. The following formula may be used to determine a reasonable, allowable error:

> Allowable error = .014 times the square root of the length of the traverse in feet divided by 100.

There is also a "rule of thumb" that may be applied to determine allowable error: If the turning point readings are approximately 150 feet in length, the allowable error may be computed by multiplying .01 feet times the number of instrument settings.

Field notes must be kept when differential leveling. Sample field notes made from the readings in Transparency No. 7 are shown in Transparencies Nos. 8a and 8b.

Transparencies Nos. 8a and 8b

7. Staking Out Fence Lines

1. The position of one corner (C) is determined. If the building is to be parallel to a farm road or another building, the farmer will want to measure the same distance back from the road or building in two places (NC and OP).
2. The level is set up and leveled with the point of the plumb bob over point C, as shown in the transparency.
3. The telescope is sighted at P and clamped in this position.
4. CD is measured so that it is the desired length of the building.
5. A stake is set at D in line with the vertical cross-hair of the telescope.
6. The telescope remains in the locked position after sighting at D, and the graduated circle is turned until one of its zeros coincides with the zero of the vernier.
7. The telescope is turned 90 degrees and sighted on point F. The distance from C to F is measured to get the desired width of the building.
8. The instrument is moved to D, and a stake for the E is set in manner as was F.
9. The points and measurements are checked for accuracy. The following procedure may be used:

    1. FE and CD should be measured and be the same.
    2. The instrument is moved to E, and the angles DE and EF are checked to see if they are 90 degrees.
    3. The two diagonals CE and FD should be measured. They should be equal.

Some buildings will have projections or re-entrant parts which will make them more difficult to lay out. A foundation of this type is shown in the bottom half of Transparency No. 5. The procedure for laying out the foundation of this type of building is as follows:

1. The main rectangle should be laid out first, and the smaller rectangles laid out afterward in the same manner. If one starts at one corner and continues around the building, errors will accumulate.
2. The rectangle ACIF should be laid out first.
3. The small rectangles are then laid out.
4. The points and measurements, as explained in laying out a rectangular foundation, should be checked on all rectangles or angles.

The batter boards are set up after the foundation is staked.

Transparency No. 6

The procedure to use for setting up batter boards is as follows:

1. The level is placed in a convenient location.

2. The height of the masonry is determined. The rod is held on the mark which designates the height of the masonry, and the target is set so it is bisected by the horizontal cross-hair of the level. The reading is taken and recorded. This reading will be used on all batter boards.
3. The batter boards at corner A are located. The board is raised or lowered until the target is in the cross-hair.
4. The height of the batter boards at the other corners is determined in the same manner.
5. String should be tied to the batter boards so that it will intersect directly over the four corners. The points where the string is attached to the batter boards should be marked. A nail may be driven at this point to hold the string, or a shallow saw cut may be made to hold the string. The string is removed while the foundation is being dug. After the foundation has been dug, the batter boards should be checked to see that they are still level.
6. The line is established by setting the level over stake A, leveling it, and sighting to stake B. A plumb bob may be used at corners to see if the string intersects the point of each stake.

6. Differential Leveling

Differential leveling is used by a farmer to determine the differences in elevation at different points on his farm. The establishment of the elevation at different points is useful in running drainage lines and building soil conservation structures. These points are referred to as bench marks, after the elevation at different points has been taken and the elevation becomes permanently established.

A bench mark may be a point on a large boulder, concrete slab, or some other permanent point or spot. A bench mark can be established by driving a length of pipe (4 feet is recommended) into the ground within one-half inch of the surface. The purpose of a bench mark is to have a point with a known elevation which can be used as a reference point to determine the elevation of unknown points.

The elevation of a bench mark may be its height above sea level, if this information is known. It is customary in farm surveys to assume the elevation of the first bench mark to be 100 feet and to determine the elevation of all other points in relation to this bench mark.

Transparency No. 7

It is assumed that the elevation at BM-1 in the transparency above is 100.00 feet. The elevation at BM-2 is to be determined. The following procedure can be used:

1. The instrument is set up at some convenient distance away from BM-1 and in the direction of BM-2. The distance will depend on the accuracy of the instrument and should not exceed 350 feet. If possible the instrument should be located near the center of two readings, BM-1 and TP-1 for example.
2. A reading is taken and recorded on BM-1. This is 3.02, as shown in transparency. This reading is known as a backsight (BS), which is a reading taken on a point of known elevation. BS readings are also known as plus sights because they are added to the elevation of the last known point to give the elevation of the line of sight. called height of instrument (HI). The HI at BM-1 is 103.02 (100.00 + 3.02).
3. The next reading is taken at TP-1 where a temporary stake is set. The instrument is not moved to take this reading, which is called a foresight (FS) reading. A FS reading is taken at a point of unknown elevation and is called a minus sight since it is subtracted from the HI to give the elevation at the new point. The elevation or HI at TP-1 in transparency is 99.34 (103.02 - 3.68). TP-1 now has a known elevation and can be used when the instrument is moved.
4. The readings are made as explained above.

The survey should be continued until a circuit is completed, as is shown in Transparency No. 7; and the last FS is taken at BM-1. This is necessary to check the accuracy of the survey.

The final reading in most cases will not be exactly the same as the 100.00 feet which was used at the start. If there is a difference between the original reading and the last reading, this indicates an error. A reasonable allowance can be made for errors. The following formula may be used to determine a reasonable, allowable error:

> Allowable error = .014 times the square root of the length of the traverse in feet divided by 100.

There is also a "rule of thumb" that may be applied to determine allowable error: If the turning point readings are approximately 150 feet in length, the allowable error may be computed by multiplying .01 feet times the number of instrument settings.

Field notes must be kept when differential leveling. Sample field notes made from the readings in Transparency No. 7 are shown in Transparencies Nos. 8a and 8b.

Transparencies Nos. 8a and 8b

7. Staking Out Fence Lines

The best instrument for staking out fences is one that can be moved vertically as well as horizontally; however, a farm level may be used.

Transparency No. 9

The procedure is the same for a completely new fence line or a new fence line at a right angle to an existing fence. The following procedure may be used:

1. The instrument is set up with the plumb bob bisecting a corner stake of a completely new fence. The telescope is pointed in the direction of the fence line, and the graduate circle is placed at zero degrees. The stakes are aligned with the vertical cross-hair. After the stakes are aligned in one fence line, one would proceed with steps 2 through 4.

   If a new fence is being staked out at a right angle to an old fence, a stake in the new fence line is driven three or four feet from the existing fence. Another stake should be driven about 20 feet from the first stake and the same distance from the fence as the first stake. This stake and the stake which the plumb bob bisects are parallel to the fence. The cross-hair in the telescope should bisect the second stake. Proceed with steps 2 through 4.
2. The graduate circle is set at zero.
3. The telescope is turned until the graduate circle reads 90 degrees and points in the direction of the proposed fence line.
4. Stakes are set in the new fence line. A tape is used to measure the distance, and the telescope is used to align the stakes.

After several stakes have been set, it may be necessary to move the instrument. When the instrument is moved, it should be set over the last stake so that the plumb bob bisects the stake. A backward sight is taken on a stake, and the graduate circle is set at zero degrees. The telescope is then turned 180 degrees. The instrument is now prepared for sighting the rest of the stakes, and the same procedure may also be used to align the posts after the holes are dug.

8. Measuring Land Areas

The purpose of this discussion is to familiarize the student with procedures that can be used for measuring different shaped land areas. If land is purchased or sold and the exact quantity is not known, it is recommended that a licensed surveyor be employed.

The most common method of measuring distances is with the use of a steel tape. Measuring distances with a steel tape is referred to by many farmers as chaining. The tape is 100 feet long; and the survey lines are measured by full tape lengths, which are called stations. Distances indicated by stations provide the number of 100-foot lengths in a surveyed line. The fractional part of the distance between a full station (100 feet) is called a plus station. For example, a point 214.8 feet beyond the starting point is designated as Station 2 + 14.8, three full tape lengths plus 14.8 feet.

In order to maintain accurate measurements, it is suggested that the rules listed below be followed:

1. Keep tape on the line being measured. It may be necessary to erect tall poles between the points being measured to stay on the line. Since two men are needed to run the chain, the second man may help the head chainman stay on the line.
2. Uniform tension should be maintained on the tape when taking each measurement.
3. The tape should be held horizontal when making measurements. In plane surveying, neglecting the curvature of the earth, all measurements on the earth's surface are considered to be on a horizontal line; therefore, to obtain accurate measurements, the tape should be held level or horizontal. It may be necessary to use a plumb bob to mark the station points accurately when the tape is held horizontal. It may be difficult to hold the tape horizontally on a steep slope. There is a method, however, that may be employed and allow the holding of the tape near the soil surface. The percent of slope must be determined between each station and a correction factor is added to the station reading.

Factors for Converting Slope Distances to Horizontal Distances

% Slope	Correction Factor	Length Along Slope to Equal 100 Feet Horizontal Distance
5	.1	100.1
6	.2	100.2
7	.2	100.2
8	.3	100.3
9	.4	100.4
10	.5	100.5
11	.6	100.6
12	.7	100.7
15	1.2	101.2
18	1.6	101.6
20	2.0	102.0
25	3.0	103.0
30	4.2	104.2

Using the above chart in an example, it is assumed that the station (one chain's length)was taken on a 15 percent slope. The correction factor for a 15 percent slope is 1.2. The 1.2 must be added to the chain's length, and the measurement would be 101.2 feet.

A hand level can be used to determine the percent of slope.

4. Either a plumb bob or correction factor must be used to mark the station point for horizontal measurements.
5. Each station should be accurately marked and accurate records kept of the number of stations.

A procedure for using the chain is outlined below. In addition to the tape, eleven pins, made of heavy wire or spikes, will be needed.

1. The two tapemen are designated as head tapeman and rear tapeman. The head tapeman carries the marking pins.
2. The head tapeman places a pin at the starting point,takes the zero end of the tape, and proceeds in the general direction of the line to be measured.
3. The rear tapeman stands at the starting point; and when the tape is pulled even with the first pin, he calls "tape."
4. At this signal, the head tapeman stops and with the assistance of the rear tapeman, who signals either to the right or left, or states "mark tape."
5. The rear tapeman holds the 100-feet mark even with the pin and calls out "right here."
6. The head tapeman pulls the tape tightly, sets the pin even with the zero mark, and calls out "right here."
7. At this signal, the rear tapeman pulls the first pin; and both tapemen advance to the next station. The same procedure is followed at 100-feet intervals.

The number of pins carried by the rear tapeman indicates the number of stations, 100-feet lengths measured. After the head tapeman has set his last pin, the rear tapeman records the number of stations (10); and delivers the pins to the head tapeman. The eleventh pin remains in the ground to mark the last point measured on the line.

If the last point measured is going to be a fractional tape length, the pin designating the last 100-feet length or station is not pulled. Mistakes are often made on the last fractional measurement. In reading this measurement, care should be taken to notice the graduations on the tape.

Measuring Angle With a Tape - It is often necessary to erect a perpendicular or right angle with respect to a line. The steel tape can be used to accomplish this. One way is to use the 3-4-5 method: A triangle is constructed with sides having multiples of 3, 4, and 5. Some desirable lengths of these multiples are 30, 40, and 50 feet and 60, 80, and 100 feet.

Transparency No. 10

Using the 3-4-5 method, a right angle is made by setting two pins 30 feet apart on the base line, AB. Then a line is marked 40 feet from point A on the base line by swinging an arc on the ground. A second arc intersecting the first arc is made on the ground by measuring 50 feet from point B.

Another method of erecting a perpendicular or angle is the chord method, which is illustrated in the above transparency. Point A is designated on the base line and points B and C are marked equal distances from point A. In the illustration, these distances are 40 feet from point A. Then a distance greater than 40 feet (80' in illustration) is used to scribe arcs on the ground. Point D is located at the bisection of these two arcs. Line AD will then be perpendicular to the base line.

USING A STEEL TAPE TO DETERMINE AREA IN A FIELD

The use of a steel tape and the application of simple rules of mathematics can be used to determine the land area in fields and pastures. Common units of measurements which may be used are listed below:

Distance
1 yard = 3 feet
1 rod = 16 1/2 feet
1 chain = 66 feet or 4 rods

Land Area
1 acre = 43,560 sq. ft.
1 acre = 4,840 sq. yds.
1 acre = 160 rods
1 acre = 10 sq. chains

Determining the Land Area in a Rectangle - In a rectangle, all of the angles are right angles or 90 degrees. The rule for figuring the area of a rectangle is follows:

$$\text{Area in Acres} = \frac{\text{Width in feet x length in feet}}{43,560}$$

Transparency Nos. 11a and 11b

An example is shown in illustration No. 1 in Transparency No. 11.

$$\text{Area in Acres} = \frac{1240 \times 560}{43,560} = 15.94 \text{ acres}$$

Determining the Land Area in a Right Triangle - The area of a triangle equals one-half the product of the base and the altitude. See illustration No. 2 in the transparency.

$$\text{Area in acres} = \frac{\text{Base in feet x Altitude in feet}}{2 \times 43{,}560}$$

$$\frac{1240 \times 550}{2 \times 43{,}560} = 7.83 \text{ acres}$$

Determing the Land Area in Any Triangle - If the triangle is not a right triangle, its altitude can be located by erecting a perpendicular line on the base to the opposite corner or angle. When measurements for the base and altitude have been determined, the calculations are same as for a right triangle (ill. No. 3).

Determining the Land Area in a Trapezoid - A trapezoid is a four-sided figure with only two sides parallel. The area of a trapezoid equals the product of one-half the sum of the two parallel sides times the altitude, or the shortest distance between the two parallel sides. Illustration No. 4 in transparency is an example.

$$\text{Area in acres} = \frac{(900 + 1200) + 500}{2 \times 43{,}560} = 12 \text{ acres}$$

Determining a Land Area Having Four Non-Parallel Sides - This is accomplished by dividing the area into two triangles and determining the areas of the triangles separately. Area in acres = $\frac{\text{Base in feet x Altitude in feet}}{2 \times 43{,}560}$

$$\text{Area No. I } \frac{1215 \times 550}{2 \times 43{,}560} = 7.67 \text{ A.}$$

$$\text{Area No. II } \frac{1325 \times 480}{2 \times 43{,}560} = 7.30 \text{ A.}$$

$$\text{Total Acres } \quad 14.97$$

Determining the Land Area Where One Side is Straight and One Boundary is Curved - The same rules as were used for trapezoid is used. The straight side is divided into equal intervals, and perpendiculars are erected and measured at each interval. The rule states that one-half the first perpendicular (HO) plus the sum of all the intermediate perpendiculars, plus one-half the last one (HN), multiplied by the interval "D" equals the area. Since the rule assumes the irregular sides are straight lines between the intersections of the perpendiculars, the result is an approximation; however, accuracy is increased as the intervals (D in illustration No. 6) between the perpendiculars are reduced. A D = 50' is more accurate than a D = 200'.

This procedure divides the area into small trapezoids with the same "D" widths and provides a method for calculating the combined area of the trapezoids into one formula.

If one end along the base line is an odd length, take the perpendicular at the end of the last full length "D", as the end perpendicular "HN". Then calculate the remaining area of irregular width separately as a simple trapezoid or triangle and add it to the area obtained by the trapezoidal rule.

$$\text{Area in acres} = \left(\frac{ho}{2} + \text{sum } h1 \text{ to } hn + \frac{hn}{2}\right) \times d$$

$$\text{Area} = \left(\frac{178}{2} + 215 + 340 + 360 + 372 + 355 + 360 + 330 + 310 \times \frac{100}{43{,}560}\right. =$$

5.91 acres

Determining the Land Area When all Sides are Curved - The rule for figuring the area of a trapezoid also may be used in this case. A base line is established through the area, and perpendicular offsets are measured as shown in illustration No. 7.

When the area comes to a point at each end of the base line and the end perpendiculars are zero, the trapezoid rule becomes even more simple because the half values of the end perpendiculars are omitted. The area equals the sum of all the intermediate perpendicular "H" measurements multiplied by "D".

Determining the Land Area in a Long Narrow Curved Area - The trapezoidal rule also may be used to determine the approximate land area with shapes similar to illustration No. 8. A center line, even though it is not straight, is measured, and widths (D) are measured at regular intervals. The approximate area can be determined by measuring the total length of the center line and multiplying by the average width. The width (D) does not have to be taken at any specific interval. An example of this method is provided below: Assume the center line is 2500 feet long and the width measurements were taken at 15 locations and average 43.5 feet.

$$\text{Area in acres} = \frac{2500 \times 43.5}{43{,}560} = 24.96\text{A}.$$

9. Reading Legal Descriptions

A legal description describes a piece of property in such a way that the property cannot be confused with another piece of property. The description of a particular piece of property can be acquired from a deed, title policy, public records, and an accredited survey. Several systems are used for describing property in the United States:

1. Government Survey System - This system is also called the rectangular survey system and is used by the Federal government. A rectangular area or unit of land is established 24 miles square and is bounded by base lines running east and west and meridians running north and south. This area is divided into six square-mile areas called townships. Each of the six square-mile areas are divided into 36 sections, each one mile square. The sections are numbered consecutively beginning with the section at the north-east corner of the township. This system is used by most states west and south of Ohio, but is seldom used in Texas.

2. Lot and Block System - Being developed from the rectangular survey method, this system is used mostly in urban areas. When used, each block and lot is numbered and entered on a plat map of the tract.

3. Metes and Bounds System - This system is used extensively in Texas and is the oldest method of describing land. Metes are measures of length-feet, inches, perches (1 perch = 16 1/2 ft.). Bounds are artificial and natural boundaries such as streets, roads, adjoining farms, and streams. While metes determine the quantity of land (acreage), bounds confine the quantity within certain fixed limits. A description of this type has a definitely ascertained starting point. The description proceeds clockwise and traces the lines by directions and distances back to the point of beginning.

   The example given in the following transparency is a legal description of an actual piece of property in a small town in Texas, which incidentally is not named Ding Dong.

Transparency No. 12

10. Irrigation Lines and Ditches

The purpose of the information in this area is to familiarize the student with the different methods of irrigation. Hopefully, it will assist him in understanding many of the factors that must be considered in planning an irrigation system. Since the systems vary among farms and the problems in planning a system are unique to a specific farm, the planning of a system is complex and generally requires the services of an engineer.

The two principal methods of irrigation are (1) surface and (2) subsurface. Since most farms use the surface method, this discussion is confined to this method.

Transparency No. 13

There are three kinds of surface irrigation in addition to the use of sprinklers, which are discussed separately. These are (1) uncontrolled flooding, (2) controlled flooding, and (3) furrows.

Uncontrolled flooding is the releasing of water from a supply ditch onto an area that does not have levees to guide or control its flow. Areas where this system is used have a cheap and plentiful supply of water. It is difficult to apply water uniformly with this method, and it is often an inefficient means of irrigating. Size of stream, depth of water released on the area, and permeability of the soil (rate of water intake) affect the efficiency of uncontrolled flooding.

Borders, checks, corrugations, or levees are used for controlled flooding. When border strips are used, the area to be irrigated is divided into a number of strips preferably 30 to 60 feet wide and 400 to 1500 feet long. Water is turned into the strips from a supply ditch at the highest end of the strip and is allowed to flow slowly toward the lower end. The size of stream turned into each strip often varies depending upon the slope and size of strip.

Check- flooding is adapted to land that is relatively level and is suited to permeable soil that must be flooded quickly to prevent excessive water losses through deep percolation or seepage into supply ditches. It is also suited to slowly permeable soils that require the holding of water to allow for penetration of water into the soil. The levees constructed for check-flooding are 6 to 8 feet wide and 10 to 12 inches high. Higher levees prevent the crossing of equipment and may prevent the growth of the crop on the levee.

The furrow method of irrigation is often used for row crops, such as milo, cotton, and vegetables. It is suited for land having some slope. Water from supply ditches is turned into the center of the furrow at the highest end and allowed to flow to the lower end. The grade of the slope should not be so great as to cause erosion.

Sprinkler systems are a very popular means of irrigating crops. The use of sprinklers usually does not require the construction of ditches or water retaining structures. Numerous kinds are manufactured, and some systems are more suited for certain conditions.

The Use of the Level and Tripod in Laying Out Irrigation Structures - The level and target rod are used to lay out water supply ditches. In order for the supply ditch to provide a constant supply of water at an adequate level along the length of the ditch, the ditch must usually be sloped. The amount of slope will vary depending upon the size of the ditch, the source of water, and whether the ditch is lined or not.

It is a fairly simple matter to provide adequate slope when laying out the ditch with a tripod and level. Assuming that one inch of slope is required for each 100 feet, the following procedure may be followed in laying out the ditch:

1. Determine the highest point in the ditch channel and record the reading on the target rod. An ideal situation would be for the highest point to be at one end of the ditch, but this is not always possible. The highest point may be near the center of the length of the ditch. If this is the case, water will have to be directed in two directions; but the same procedure would be followed.

2. Add one inch to the highest point reading and place the target on this reading.

3. Walk 100 feet from the first reading, and move the rod up or down hill until the cross-hairs in the level match the cross on the target.

4. Add one inch to the second reading and move the target to this reading. This will be the reading for the third 100-foot station. One inch is added for each 100 feet until the ditch has been laid out.

Contour levees are sometimes used to control water in strips. These may be laid out on the level, or given some slope. If the contours are laid out on the level, the same reading on the target is used for each 100-foot station. If slope is provided for the levee layout, the same procedure is followed as was used for laying out ditches.

Credit is given to Vocational Agriculture Service University of Illinois, Urbana, Illinois for much of the information contained in this topic.

References:

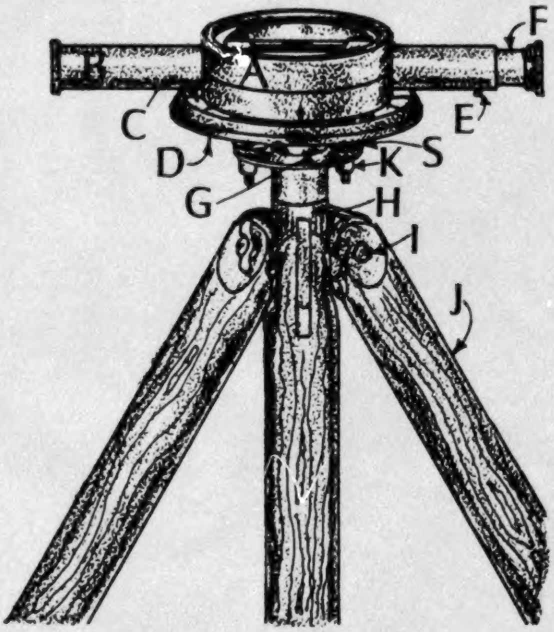
1. "Farm Surveying", Vocational Agriculture Service, University of Illinois, Urbana, Illinois, 1970

2. Ayres, Quincy C. Land Drainage and Reclamation, McGraw-Hill Book Company, Inc., New York, New York,

3. "The Farm Level", Kansas State College, Manhattan, Kansas,

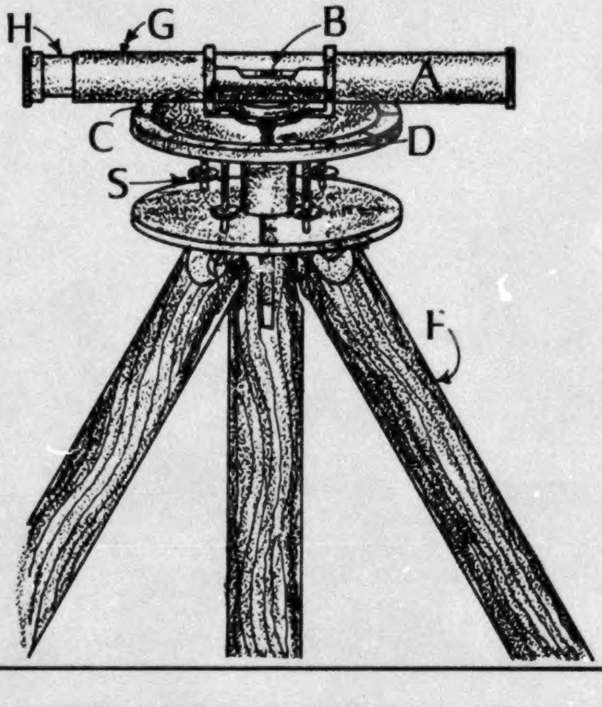
4. "Planning for An Irrigation System", The American Association for Vocational Instructional Materials, Engineering Center, Athens, Georgia, 1971

PARTS OF FARM LEVELS



TURRET TYPE

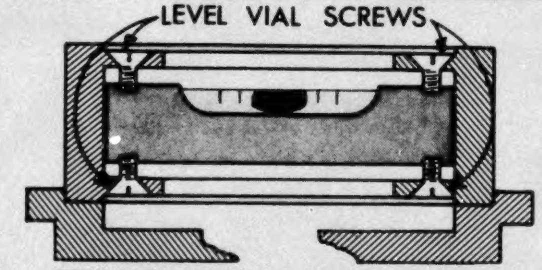
A - TURRET
B - TELESCOPE TUBE
C - GRADUATED CIRCLE
D - LEVELING PLATE
E - SLIDE SCREW
F - SLIDE TUBE
G - LEVELING HEAD
H - TRIPOD HEAD
I - LEG BOLTS
J - TRIPOD LEGS
K - BOSS
S - LEVELING SCREWS



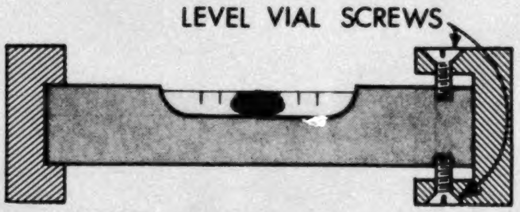
UTILITY TYPE

A - TELESCOPE
B - LEVEL TUBE
C - GRADUATED CIRCLE
D - INDEX ARM
E - BASE PLATE
F - TRIPOD LEGS
G - SLIDE SCREW
H - SLIDE TUBE
S - LEVELING SCREWS

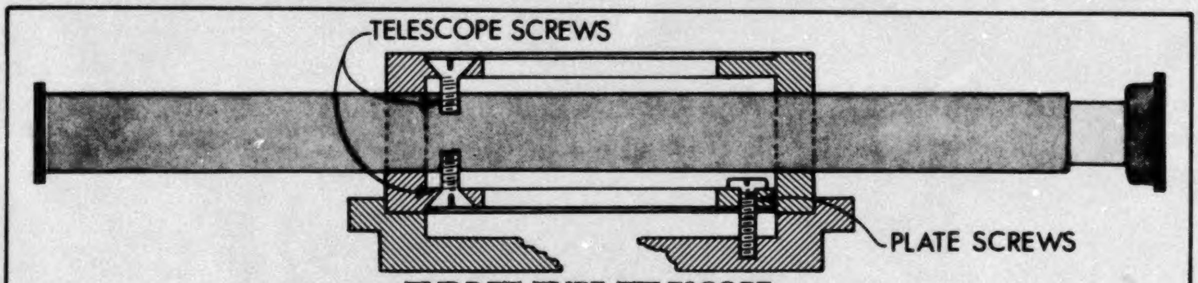
BUBBLE TUBE, TELESCOPE, AND CROSS HAIR


LEVEL VIAL SCREWS

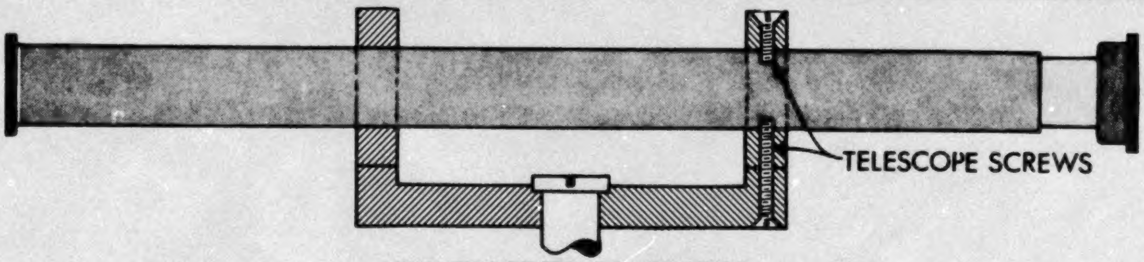
TURRET TYPE BUBBLE TUBE


LEVEL VIAL SCREWS

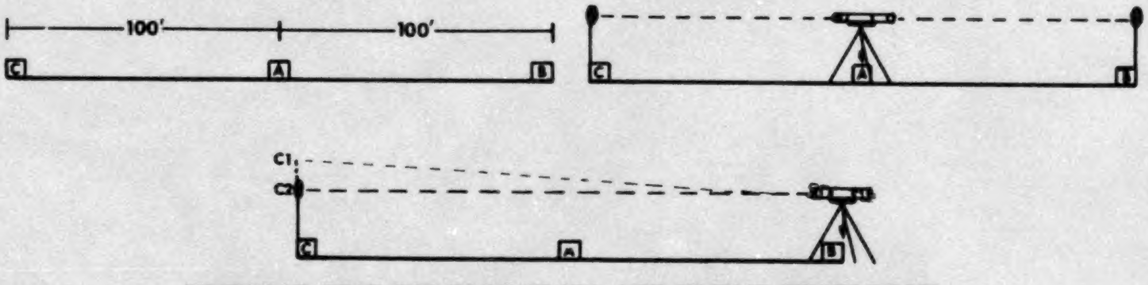
UTILITY TYPE BUBBLE TUBE


TELESCOPE SCREWS
PLATE SCREWS

TURRET TYPE TELESCOPE

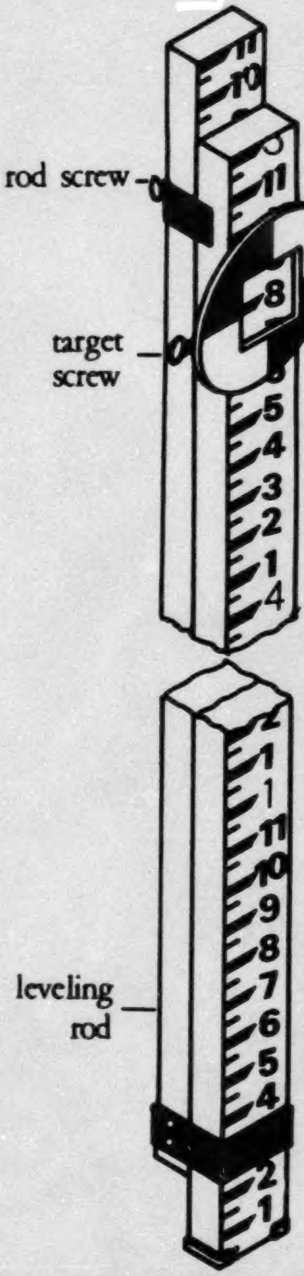

TELESCOPE SCREWS

UTILITY TYPE TELESCOPE


100'
100'
C
A
B
C
A
B
C1
C2
C
A
B

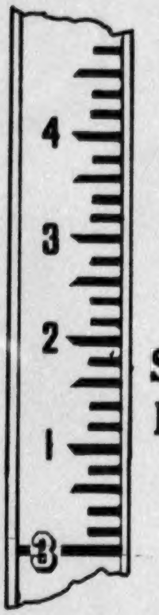
TESTING THE TELESCOPE TO SEE IF THE TELESCOPE IS IN THE LINE OF SIGHT OF THE LEVEL

TARGET RODS

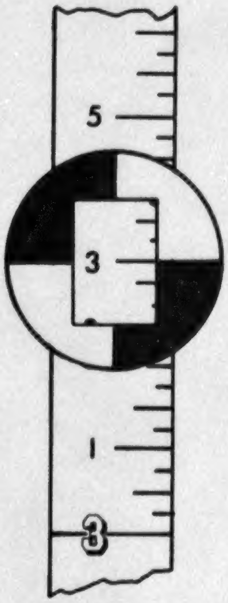


rod screw
target
target screw
leveling rod
11
10
11
8
5
4
3
2
1
4
2
1
1
11
10
9
8
7
6
5
4
2
1

PHILADELPHIA

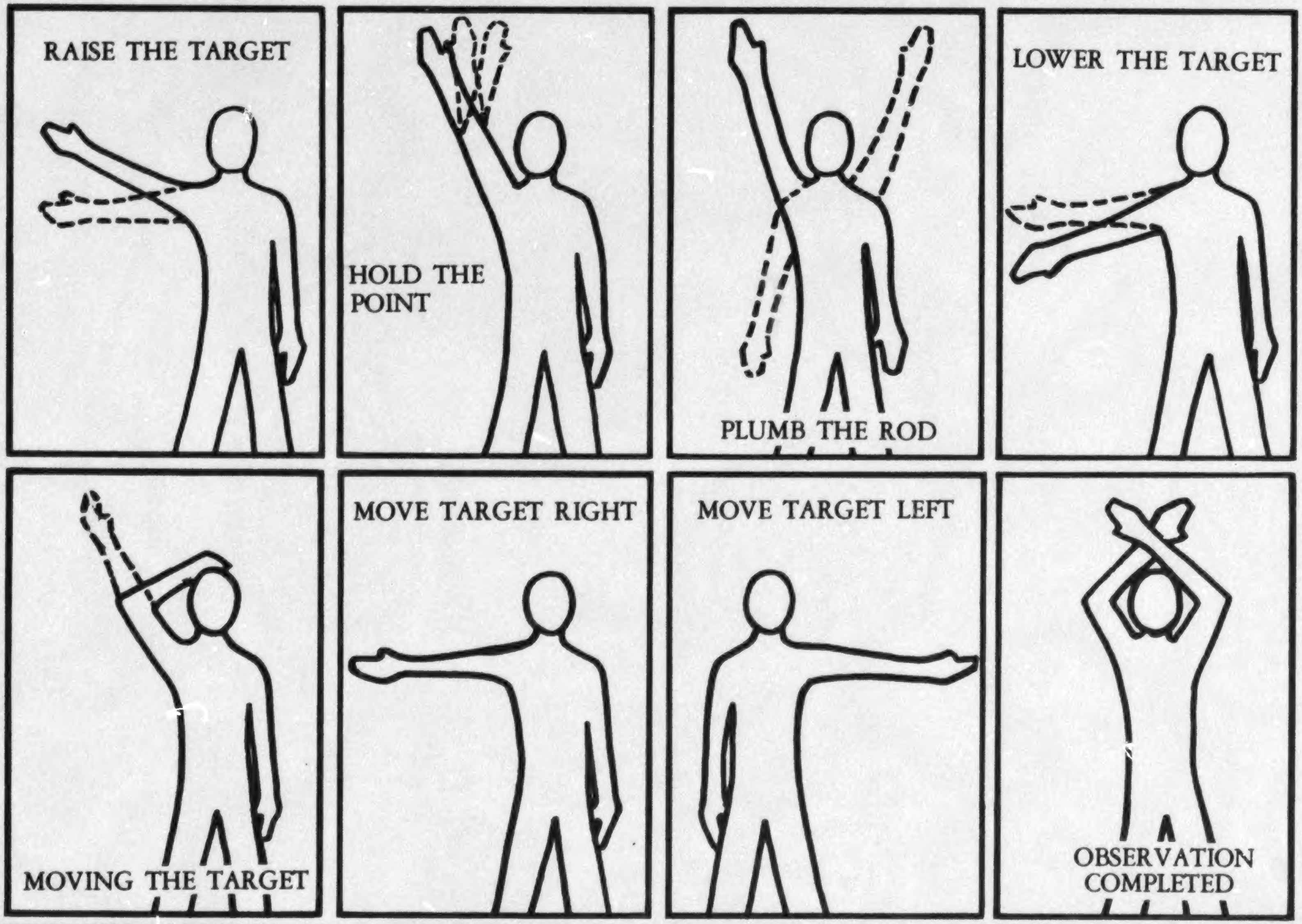


SELF LEVELING

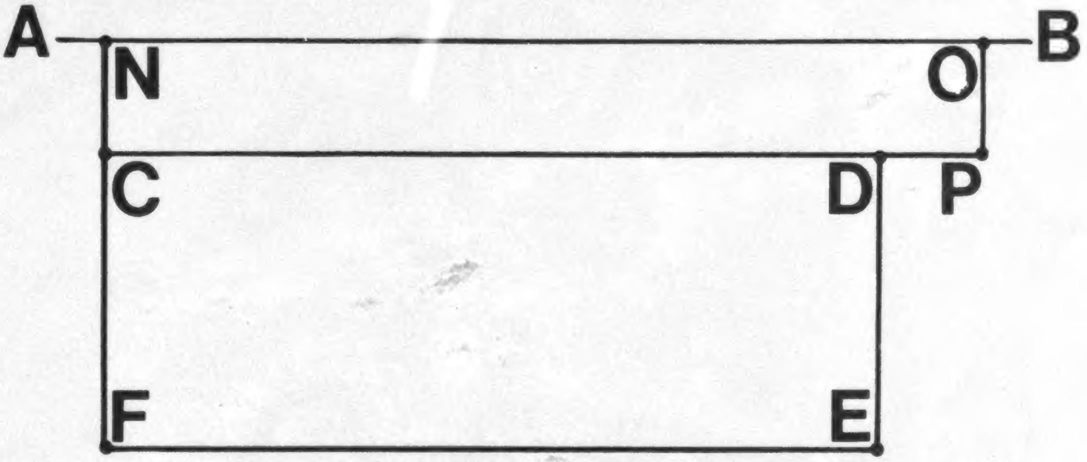


ARCHITECT

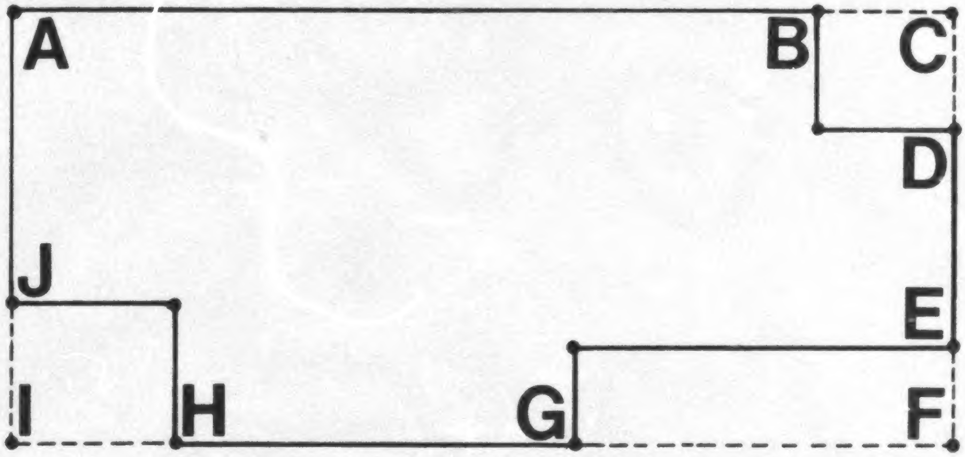
ROD HOLDER'S HAND SIGNALS


RAISE THE TARGET
HOLD THE POINT
PLUMB THE ROD
LOWER THE TARGET
MOVING THE TARGET
MOVE TARGET RIGHT
MOVE TARGET LEFT
OBSERVATION COMPLETED

STAKING OUT A BUILDING FOUNDATION

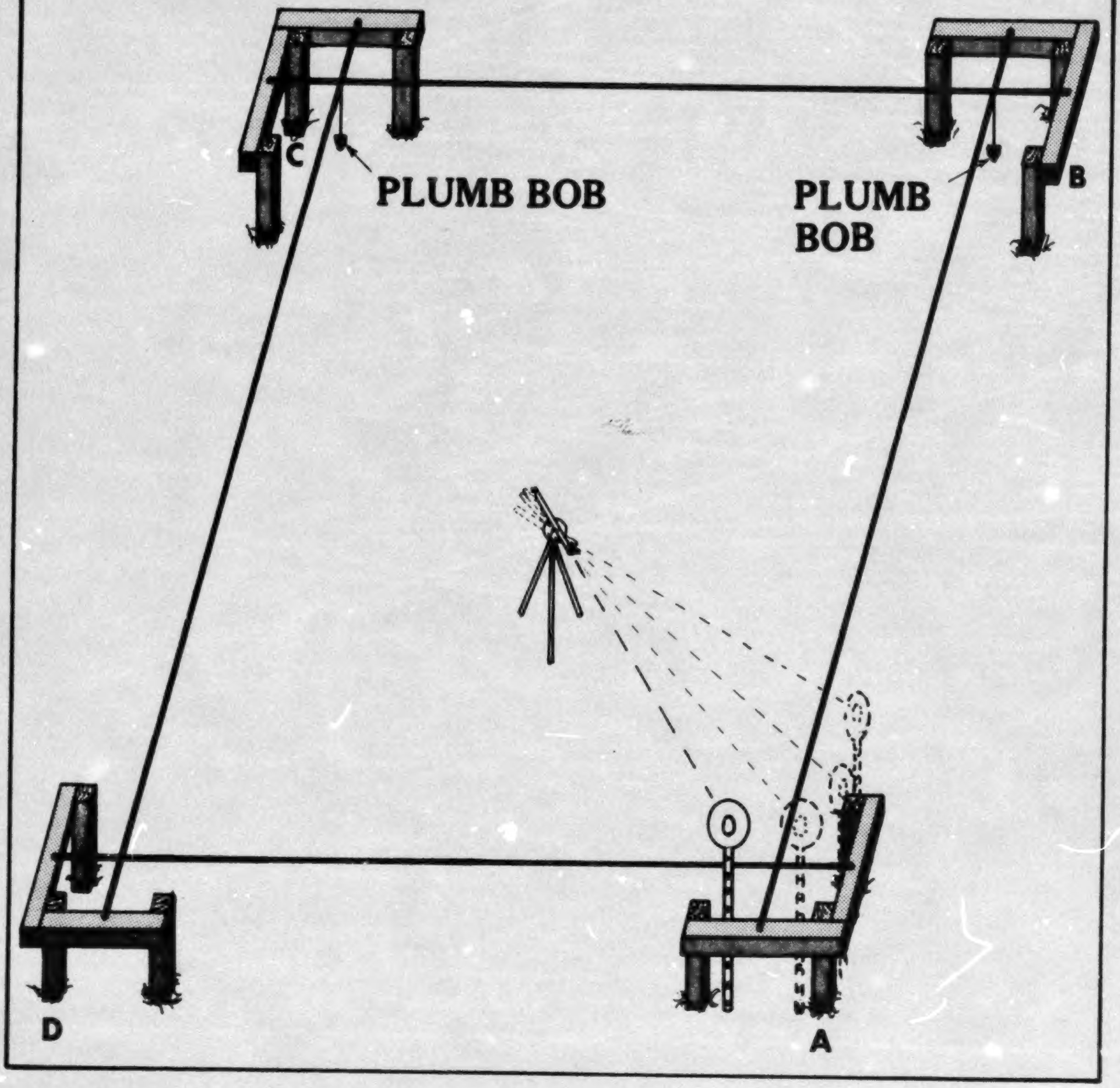


A RECTANGULAR BUILDING

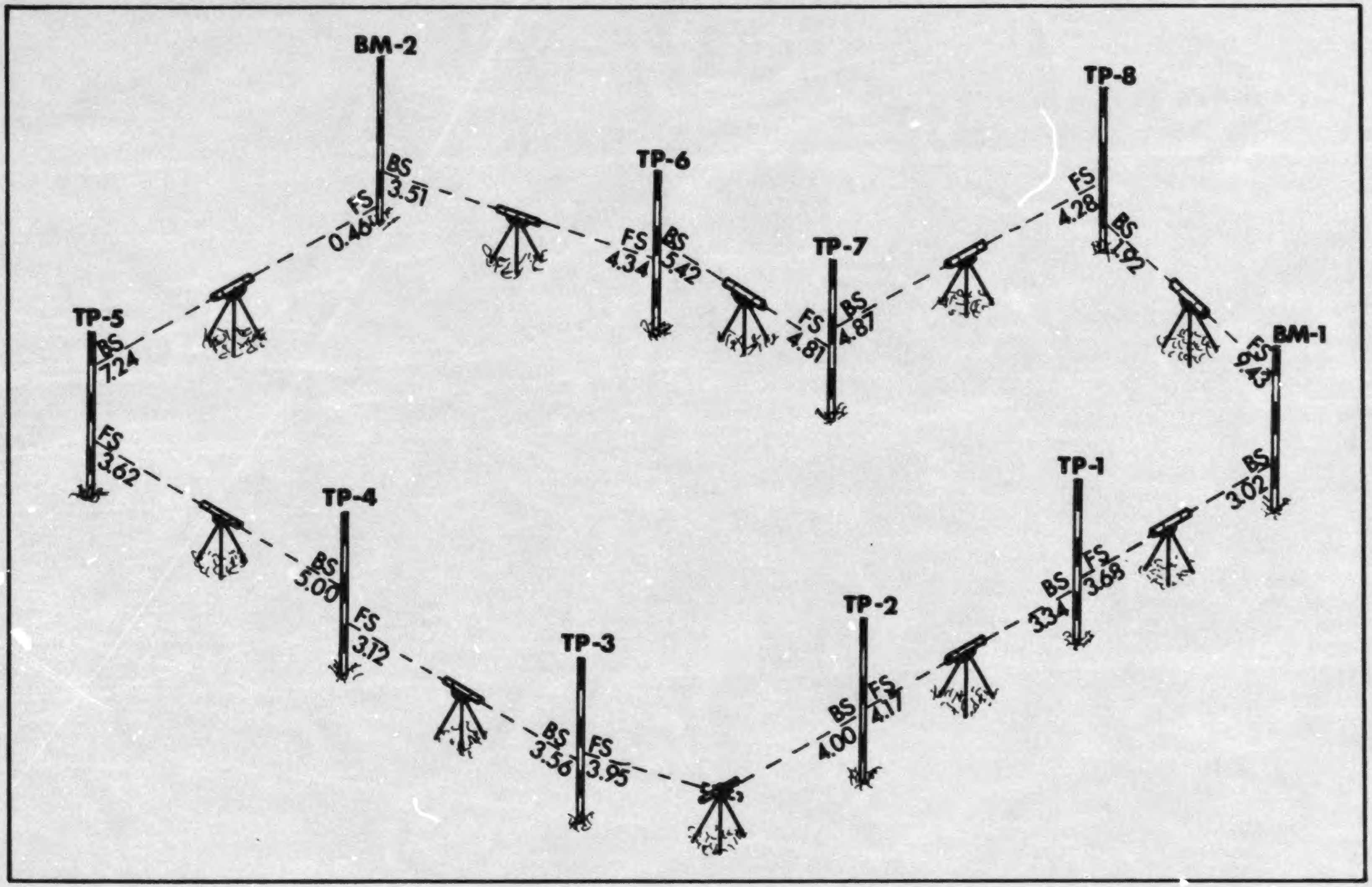

A
B
C
D
J
E
I
H
G
F

A BUILDING WITH PROJECTIONS OR RE-ENTRANT PARTS

SETTING UP THE BATTER BOARDS


C
PLUMB BOB
PLUMB BOB
B
D
A

AN EXAMPLE OF DIFFERENTIAL LEVELING


BM-2
BS 3.51
FS 0.46
TP-6
FS 4.34
BS 5.42
TP-7
FS 4.87
BS 4.87
TP-8
FS 4.28
BS 1.92
BM-1
FS 9.43
BS 3.02
TP-5
BS 7.24
FS 3.62
TP-4
BS 5.00
FS 3.12
TP-3
BS 3.56
FS 3.95
TP-2
BS 4.00
FS 4.17
TP-1
BS 3.34
FS 3.68

Vocational Instructional Services

Gen. Ag. Mech.

935-T-1
No. 7

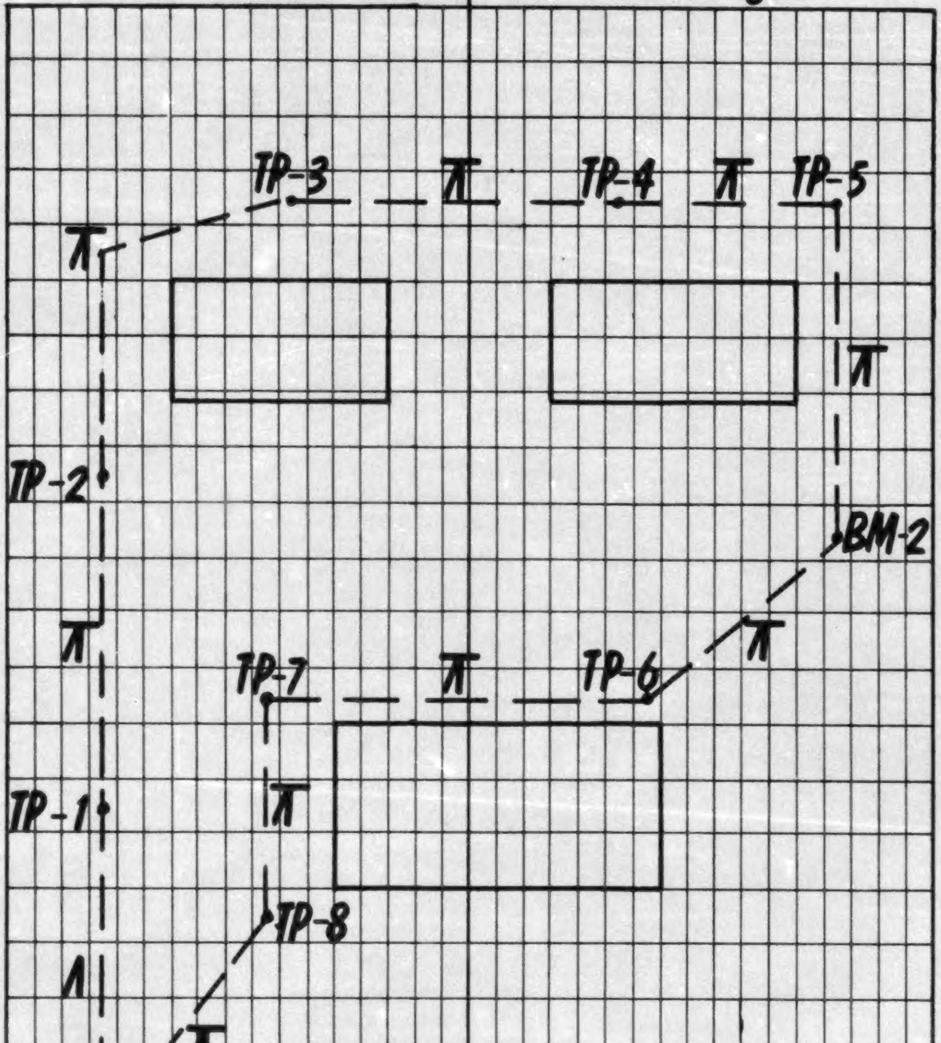
DIFFERENTIAL LEVELING FIELD NOTES

Differential Leveling

Sta.	BS	HI	FS	Elev.	Dist.
BM-1	3.02			100.00	
		103.02			250
TP-1	3.34		3.68	99.34	
		102.68			270
TP-2	4.00		4.17	98.51	
		102.51			330
TP-3	3.56		3.95	98.56	
		102.12			300
TP-4	5.00		3.12	99.00	
		104.00			320
TP-5	7.24		3.62	100.38	
		107.62			370
BM-2	3.51		0.46	107.16	
		110.67			320
TP-6	5.42		4.34	106.33	
		111.75			280
TP-7	4.87		4.81	106.94	
		111.81			310
TP-8	1.92		4.28	107.53	
		109.45			260
BM-1			9.43	100.02	
					3010
		Error =	0.02'		

DIFFERENTIAL LEVELING FIELD NOTES (Cont.)

July 22, 1971 clear, warm, calm | Palmer-⊼ Cowling-⌽

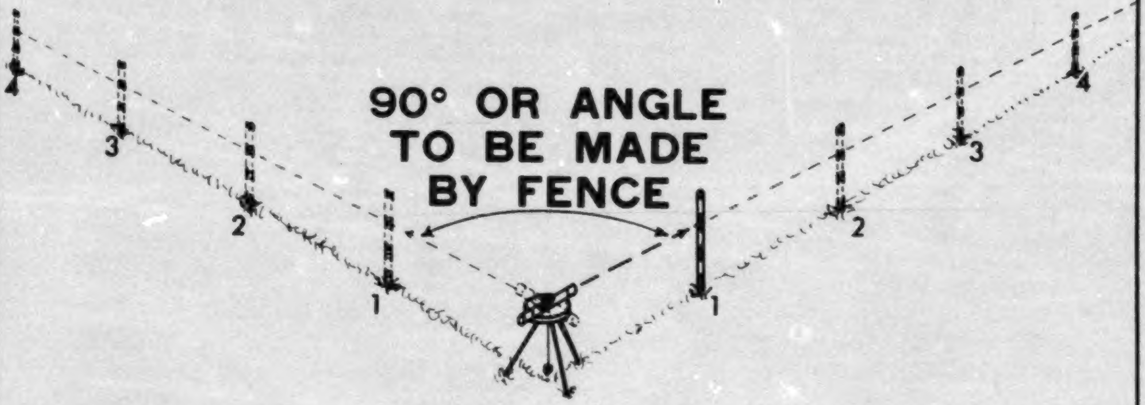

TP-3
⊼
TP-4
⊼
TP-5
⊼
⊼
TP-2
BM-2
⊼
⊼
TP-7
⊼
TP-6
TP-1
⊼
TP-8
⊼
⊼
BM-1

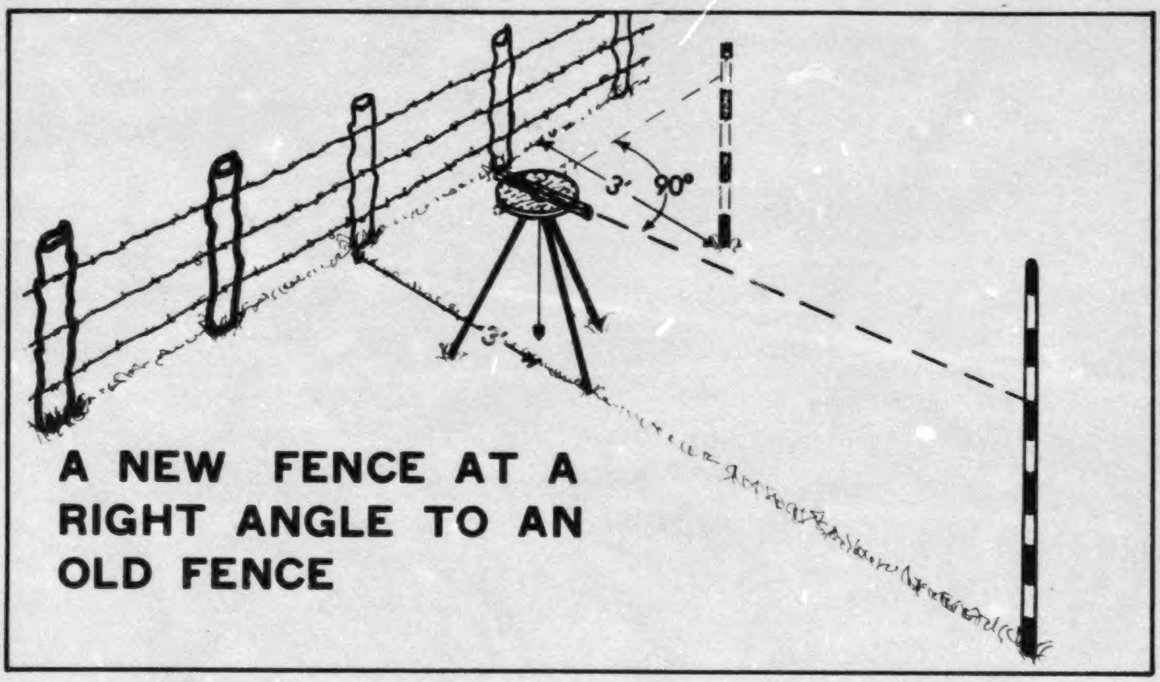
Allowable Error - $.014\sqrt{\frac{3010}{100}}$

- 0.08'

STAKING OUT FENCE LINES

COMPLETELY NEW FENCE

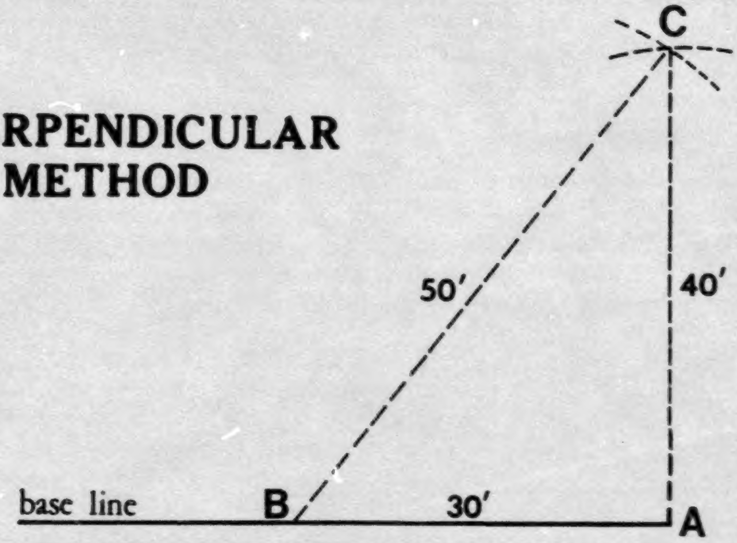

90° OR ANGLE
TO BE MADE
BY FENCE
1
2
3
4
1
2
3
4



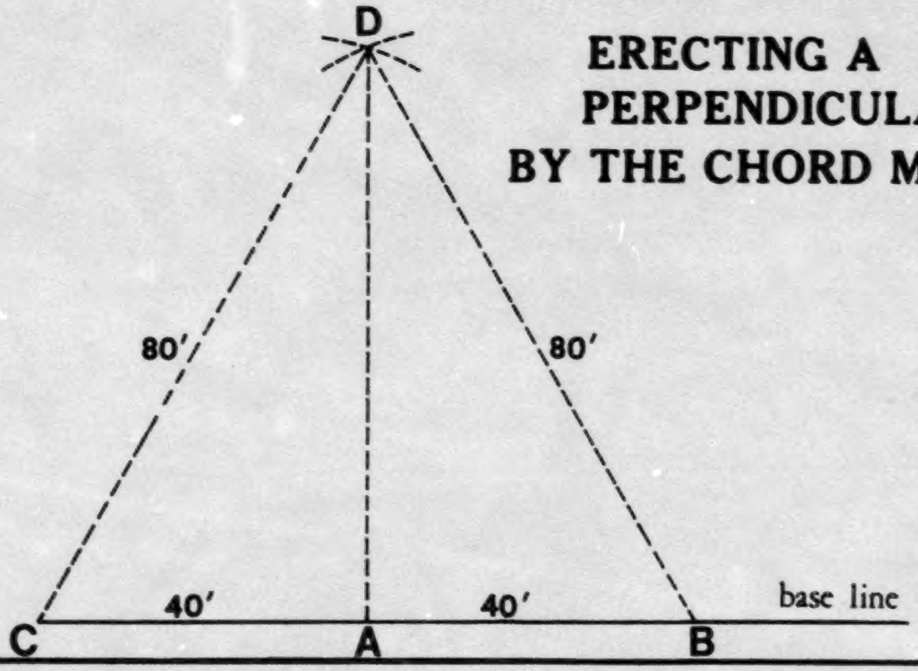
A NEW FENCE AT A RIGHT ANGLE TO AN OLD FENCE

MEASURING ANGLES WITH A STEEL TAPE

ERECTING A PERPENDICULAR BY THE 3-4-5 METHOD

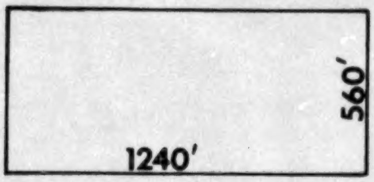

C
50′
40′
base line
B
30′
A

ERECTING A PERPENDICULAR BY THE CHORD METHOD


D
80′
80′
40′
40′
base line
C
A
B

DETERMINING LAND AREAS

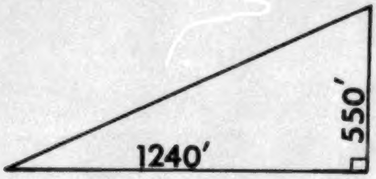
①



RECTANGLE

$$\frac{1240 \times 560}{43{,}560} = 15.94 \text{ ACRES}$$

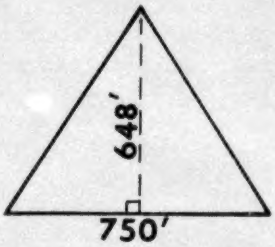
②



RIGHT TRIANGLE

$$\frac{1240 \times 550}{2 \times 43{,}560} = 7.83 \text{ ACRES}$$

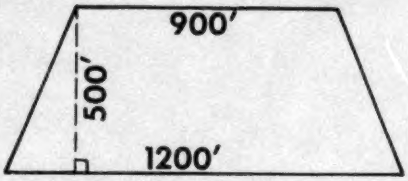
③



ANY TRIANGLE

$$\frac{750 \times 648}{2 \times 43{,}560} = 5.57 \text{ ACRES}$$

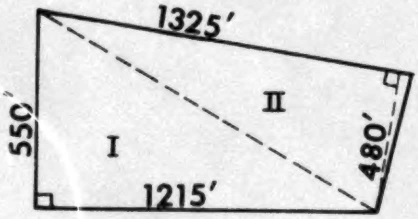
④


900'
500'
1200'

TRAPEZOID

$$\frac{(900 + 1200') \times 500}{2 \times 43{,}560} = 12 \text{ ACRES}$$

⑤


1325'
II
550'
I
480'
1215'

FOUR-SIDED AREA, NON-PARALLEL SIDES

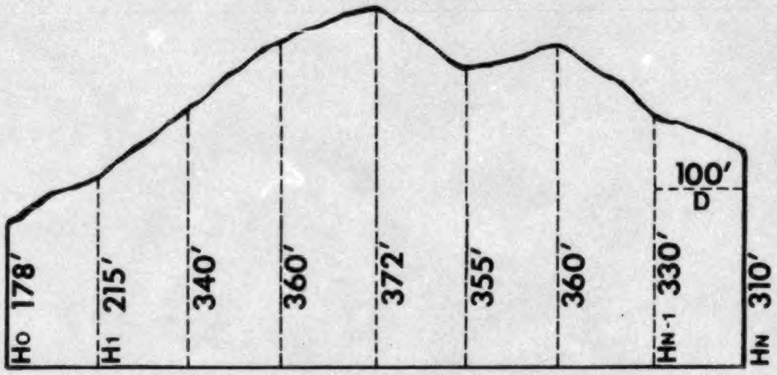
AREA I IN ACRES → $\frac{1215 \times 550}{2 \times 43{,}560} = 7.67$

AREA II IN ACRES → $\frac{1325 \times 480}{2 \times 43{,}560} = 7.30$

TOTAL ACRES 14.97

DETERMINATING LAND AREAS

⑥



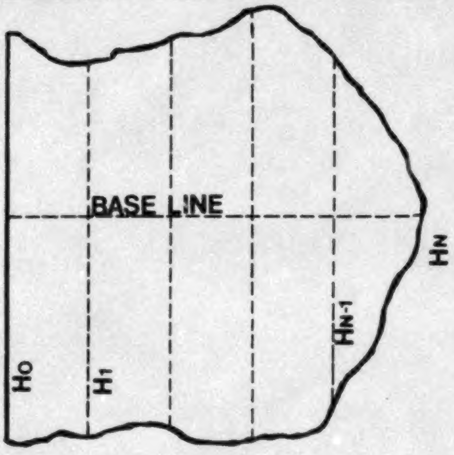
100'
D
Ho 178'
H1 215'
340'
360'
372'
355'
360'
HN-1 330'
HN 310'

ONE STRAIGHT SIDE, ONE CURVED BOUNDARY

$$\text{AREA} = \left(\frac{H_O}{2} + \text{SUM } H_1 \text{ TO } H_{N}\text{-}1 + \frac{H_N}{2}\right) \times D$$

$$\text{AREA} = \left(\frac{178}{2} + 215 + 340 + 360 \quad 372 + 355 \quad 360 + 330 + \frac{310}{2}\right) \times \frac{100}{43{,}560} = \underset{\text{ACRES}}{5.91}$$

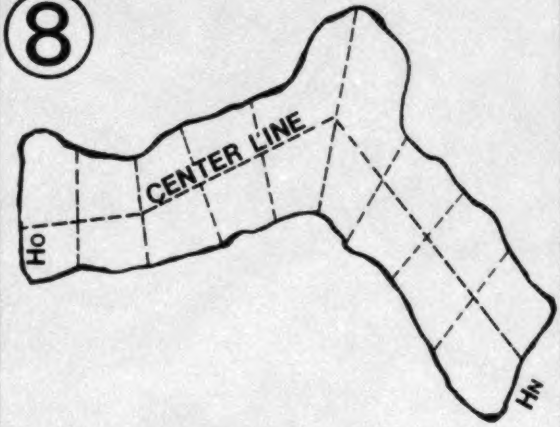
⑦



BASE LINE
Ho
H1
HN-1
HN

AREA WITH BOTH SIDES CURVED

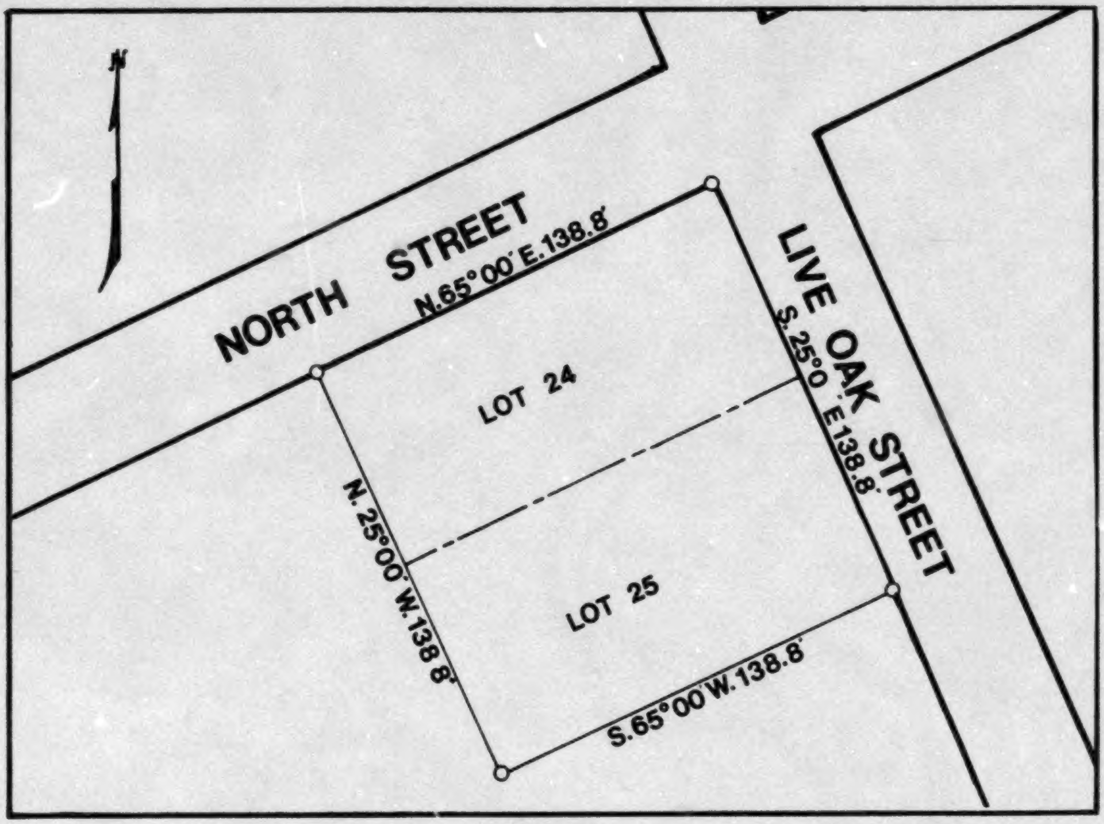
⑧



CENTER LINE
Ho
HN

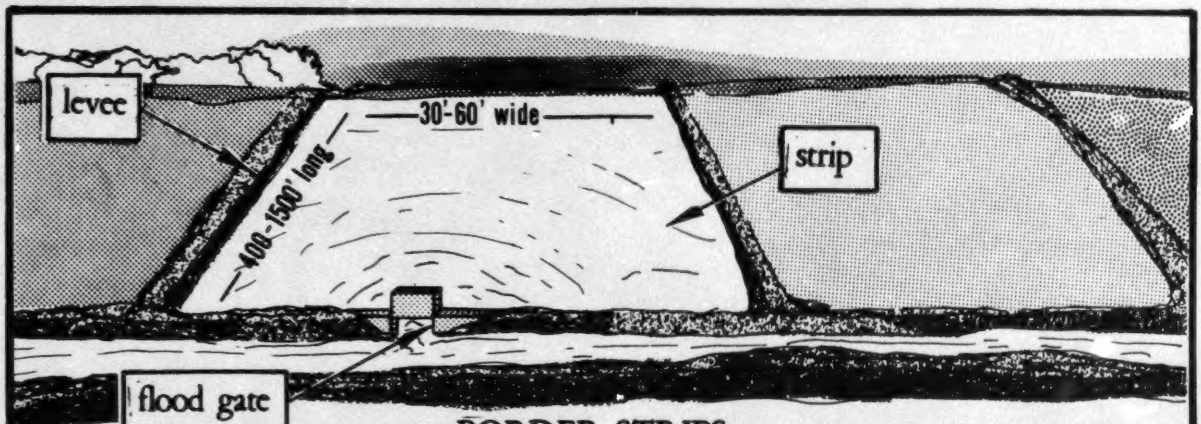
LONG, NARROW, CURVED AREA

DESCRIPTION BY METES AND BOUNDS

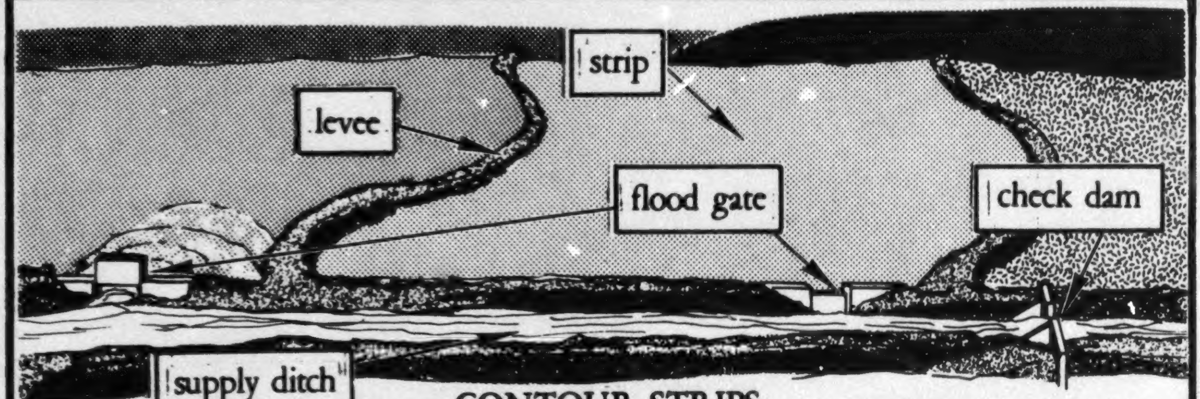

N
NORTH STREET
N.65°00'E.138.8'
LIVE OAK STREET
S.25°0'E.138.8'
LOT 24
N.25°00'W.138.8'
LOT 25
S.65°00'W.138.8'

A DESCRIPTION OF TWO LOTS BY METES AND BOUNDS: BEGINNING AT AN IRON PIPE SET FOR THE S. W. CORNER OF THE INTERSECTION OF LIVE OAK STREET AND NORTH STREET IN DING DONG, TEXAS, BEING THE N. CORNER OF SAID LOT NO. 24; THENCE WITH THE W. LINE OF LIVE OAK ST. S. 25 DEGREES E. 138.8 FEET TO PIPE SET FOR THE E. CORNER OF SAID LOT 25; THENCE S. 65 DEGREES W. 138.8 FEET TO PIPE SET FOR THE S. CORNER OF SAME LOT 25; THENCE N. 25 DEGREES W. 138.8 FEET WITH THE S. W. END OF LOTS 25 AND 24 TO AN IRON PIPE SET FOR CORNER IN THE S. LINE OF NORTH STREET; THENCE WITH THE SAID S. LINE OF NORTH STREET N. 65 DEGREES E. 138.8 FEET TO THE PLACE OF BEGINNING.

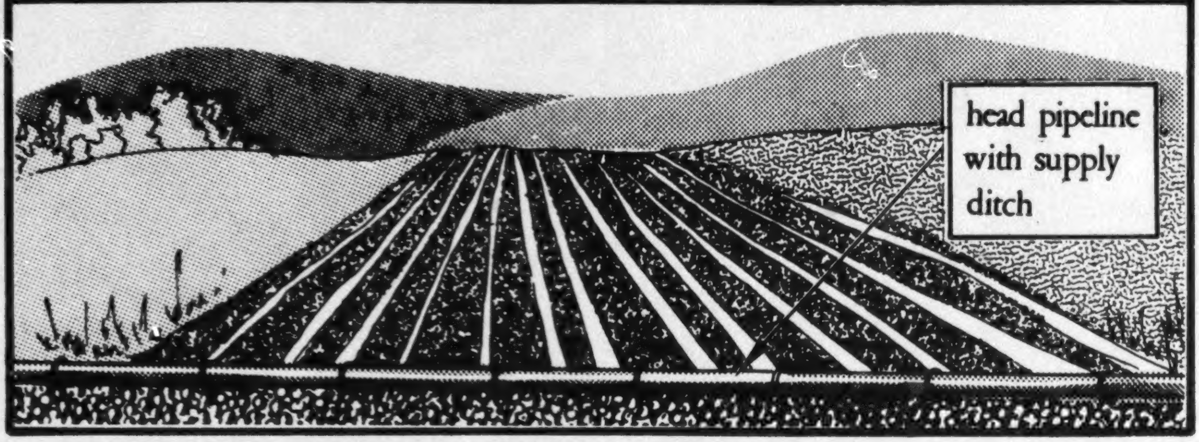
SURFACE IRRIGATION


levee
30'-60' wide
400'-1500' long
strip
flood gate

BORDER STRIPS


strip
levee
flood gate
check dam
supply ditch

CONTOUR STRIPS


head pipeline
with supply
ditch